AD_____

Award Number: DAMD17-00-C-0031

TITLE: Modeling for Military Operational Medicine Scientific and Technical Objectives (Articulated Human Biomechanical Modeling Toolbox)

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REPORT DATE: December 2000

TYPE OF REPORT: Final, Phase I, Part II

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

# REPORT DOCUMENTATION PAGE

*Form Approved*
*OMB No. 074-0188*



| 1. AGENCY USE ONLY (Leave blank) | 2. REPORT DATE | 3. REPORT TYPE AND DATES COVERED |
|---|---|---|
| | December 2000 | Final, Phase I, Part II ( ) |

**4. TITLE AND SUBTITLE**
Modeling for Military Operational Medicine Scientific and Technical Objectives (Articulated Human Biomechanical Modeling Toolbox)

**5. FUNDING NUMBERS**
DAMD17-00-1-0031

**6. AUTHOR(S)**
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**8. PERFORMING ORGANIZATION REPORT NUMBER**

**9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)**
U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**

**11. SUPPLEMENTARY NOTES**
Report contains color.

**12a. DISTRIBUTION / AVAILABILITY STATEMENT**
Approved for Public Release; Distribution Unlimited.

**12b. DISTRIBUTION CODE**

**13. ABSTRACT** *(Maximum 200 Words)*

**14. SUBJECT TERMS**

**15. NUMBER OF PAGES**
139

**16. PRICE CODE**

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| Unclassified | Unclassified | Unclassified | Unlimited |


J00-3150.31-136

# Articulated Human Biomechanical Modeling Toolbox

## *Phase I Report*
## *Part II: Toolbox Routines*

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Contract No. DAMD17-00-C-0031

December 2000

JAYCOR

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# 1. Introduction

This report documents the progresses on developing a human biomechanical modeling toolbox during the first phase of the research project. It is separated into two parts. A separate first part consists of an overview of the toolbox, rigid body formulations, and example models and applications. This second part provides detailed description of individual routines in the toolbox.

The second chapter describes the data format used in the toolbox. Data I/O, conversion and file format routines are listed in the chapter. A graphical editor for editing TMT files, TMTEDITOR, is also developed. Details on TMTEDITOR is given in Appendix A. Chapter three lists routines related to rigid body dynamics, including kinematic calculation, inverse dynamic analysis and forward dynamic simulation. Chapter four provides details of graphical routines, including routines related to the creation and manipulation of 3D graphical objects, user interface handling, animation and other graphical operation. Details on two graphical viewers, xyviewer and stickviewer, can be found in Appendix B and Appendix C respectively. Chapter five describes other utility routines related to mathematical calculation and string manipulation.

# 2. File Format and Data I/O Routines

# Data Types of Toolbox Routines

Most data types of Matlab, including *double, char, cell,* and *struct* used to develop the toolbox routines. Detailed description of these data types can be found in matlab manual. The use of user defined data type (object) is intentionally avoided. This is because the current version of Matlab compiler does not support objects in generating standalone application, while one of the guidelines of developing the toolbox routines is the full support of generating standalone application.

Data types, *double, char, cell,* and *struct,* as supported in MATLAB, are simplified and customized for the development of toolbox routines. The simplification is made to facilitate the preparation of input and output data of the routines while maintaining the capability of handling complex data. Each data type supports single or multiple dimensional arrays. The details of the supported data types are given in Table 2-1.

**Table 2-1. Data Types Used in Toolbox Routines**

| Type | | | Example | Description |
|---|---|---|---|---|
| ARRAY | *Double* | Integer | `10` | Double precision numerical array. Notice that<br>1. Complex numbers are not supported<br>2. Arrary dimension is limited to two<br>3. A space in a numeric array indicates the following elements be put in row-wise<br>4. A semicolon (;) indicates the following elements be put column-wise |
| | | Real number | `-10.1` | |
| | | Column vector | `[1;2;3;4;5]` | |
| | | Row vector | `[1 2 3 4 5]` | |
| | | Matrix | `[1 2 3; 4 5 6]` | |
| | *String* | A string | `'this is a string'` | Character arrays are put between two primes (`'`). Two consecutive primes indicates a prime inside a string<br><br>Curly brackets represent cell arrays. Only single dimensional cells of strings are supported |
| | | A string | `'It''s good'` | |
| | | A string cell | `{'string 1' 'string2' 'string 3'}` | |
| | *Structure* | A simple structure | `S.name = 'name'`<br>`S.data = [1 2; 3 4]` | Structure arrays have field names. The fields contain other arrays, including structures. This is a very general data type that can collect related data and information together.<br><br>Only one dimensional structure array is supported |
| | | A more complex structure | `S(2).name = 'name'`<br>`S(2).data.a = 1`<br>`S(2).data.b = [1 4]` | |

# Data Import and Export

An application program has to input and output data. The data may be imported from and exported to files, graphics user interfaces (GUIs), and other application programs. For example, a pre-processor usually inputs data from GUI and/or some descriptive files and generates data files for a solver. A solver may read from the files the solver parameters, time history data, tables, etc. and performs the calculation. The calculation results are usually saved as files or exported directory to post-processor for the analysis of results.

The toolbox is designed to have the capability of developing the whole application program from pre-processor to solver to post-processor, as well as the flexibility of being only part of the application program. Therefore, a common data interface supporting the data types used in the toolbox routines is essential. An application program developed from toolbox routines support the following three types of files

- MATLAB default binary file (MAT file) is the primary file format used to share data. This format supports all data types of matlab and is platform independent.
- Tagged matlab text file format (TMT file format) is developed as the ASCII counterpart of MAT file. TMT files support most data types used in toolbox routines with certain limitations. TMT files are used to share application parameters and time history data. The details on TMT files are given in section <Tagged Matlab Text Files>.
- Customized file formats. The toolbox also provides routines to interface with some customized file formats. The details on these file interface routines are described in section <Other File Format>

# Tagged Matlab Text Files

## Data Types Supported

The data types as described in Table 2-1 are supported.

## Syntax

Structure array, as described in Table 2-1, is a data type with named *"data containers"* called *fields*. The fields of a structure can contain any type of data including *double, char, cell,* or another *structure array*. Therefore, structure allows storing dissimilar data according to their physical meaning and thus facilitates the data storage and reference among routines.

**(a) TMT File (sample.tmt)**

```
This is a sample TMT file

<NUM integer> 10;
<NUM number> -10.1;
<NUM col_vector> 1;
                 2;
                 3;
                 4;
                 5;
<NUM row_vector> 1 2 3 4 5;
<NUM matrix> 1 2;
             3 4;
<NUM thist> <TAB tdata col
1 4 5>
</NUM>
this is a comment line
<CHA char> ' a string'
<CHA cell> 'string 1'
           'string 2'
</CHA>
this is a comment line
<STR struct>
     <CHA name> 'name'
     <STR data>
          <NUM a> 1;
          <NUM b> 2;
     </STR>
</STR>
```

**(b) Structure S**

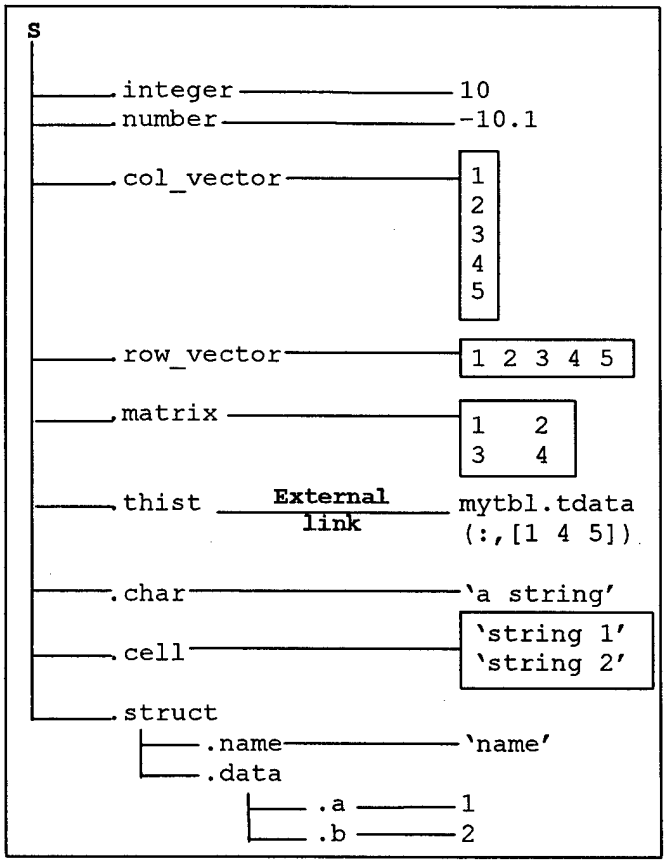



**Figure 2-1 Example of a TMT file and the Corresponding Data**

A TMT file, in essence, is the representation of a structure in an ASCII file. The *fields* of the structure are defined in the file by using a number of *tags* and simple syntaxes. Figure 2-1 gives an example of a TMT file and the structure it represents.

A TMT file ignores all line breaks, which means it is equivalent to write the whole file in one line or break it into hundreds of lines. As shown in Figure 2-1(a), a TMT files consists of three parts: *tags, contents* and *comments*. Tags include *Field Declaration Tags, Field Closure Tags,* and *External Link Tags*. The details of the use of tags are given in Table 2-2

**Table 2-2. Syntax of Tag Components of a TMT file**

| Type | Syntax | Description |
|---|---|---|
| Field Declaration Tags | <STR *name(dim)*><br>or<br><STR *name)*> | Declare that the following data are fields of the *dim*$^{th}$ component of structure *name* until </STR> tag is met.<br>Default dimension of one is assumed when *(dim)* is not present<br>Must always be paired by </STR> |
| | <NUM *name*> | Declare the following *numeric contents* to be the value of *name* until a new <STR>, <NUM>, <CHA>, </STR>, </NUM>, and </CHA> is met |
| | <CHA *name*> | Declare the following *string cell contents* to be the value of *name* until a new <STR>, <NUM>, <CHA>, </STR>, </NUM>, and </CHA> is met |
| Field Closure Tags | </STR> | Close a structure declaration. Must always be used to pair <STR>. |
| | </NUM > | Used optionally to pair with <NUM>. Usually only required when comment after a <NUM> declaration |
| | </CHA> | Used optionally to pair with < CHA >. Usually only required when comment after a < CHA > declaration |
| External Link Tags | </TAB *name*<br>COL *id* ><br>or<br></TAB *name*<br>ROW *id* > | Used as part of the *contents* after <NUM> declaration to load numerical matrices (tables) from an external data structure.<br>*name* is the field name of the external data structure where the data is to be loaded<br>COL or ROW indicates load data column-wise or row-wise<br>*id* is the indice of the rows or columns to be loaded |

Notice the following rules apply to the tags.

- Only the first three characters of tag keywords **STRucture, NUMerics, CHAracter, TABle, COLumn,** and **ROW,** are discriminated. All the following characters are ignored.
- Tag keywords are case insensitive
- Field name declaration inside any tag is case sensitive

Two types of contents, i.e., *numeric content* and *string cell content* are described in Table 2-3.

**Table 2-3. Syntax of Tag Components of a TMT file**

| Type | Example | | Description |
|---|---|---|---|
| Numeric Content | Number | 10 | A space inside a numeric content indicates the following data be collocated column-wisely<br>A semicolon (;) indicates the following data be collocated column-wisely<br>The size of matrix must match when input numerical content |
| | Column vector | 1;2;3;4;5; | |
| | Row vector | 1 2 3 4 5; | |
| | Matrix | 1 2; 3 4; | |
| String Cell Content | String | 'string' | Any string content must be put inside a pair of primes (')<br>A prime inside a string must be indicated by two consecutive primes ('')<br>Strings and string cells are always saved in data type *cell of string* when loaded |
| | String | 'It''s a string' | |
| | String cell | 'string 1'<br>'string 2'<br>'string 3' | |

Any contents outside a *Field Declaration Tag* and its corresponding *Field Closure Tag* is treated as comments and is ignored. Notice in order to add comments after a **<NUM>** or a **<CHA>** tag, optional **</NUM>** or **</CHA>** tag must be used.

## An Example of Using Tmt Files

Two interpreting routines are developed. ***tmt2struct*** reads a TMT file and converts it into a structure. ***struct2tmt*** saves a structure into a TMT file.

An example is given to shown the use of these routines and load data from external structures. First, save the TMT file as *'sample.tmt'*. In order to load this file, an external structure, say *mytbl* with a field named *tdata* must exist. The external structure can be generated from another TMT file, say *'data.tmt'* as follows

**DATA File (data.tmt)**

```
This is a sample data file

<NUM tdata>
    11    12    13    14    15    16    17    18    19;
    21    22    23    24    25    26    27    28    29;
    31    32    33    34    35    36    37    38    39;
    41    42    43    44    45    46    47    48    49;
    51    52    53    54    55    56    57    58    59;
    61    62    63    64    65    66    67    68    69;
    71    72    73    74    75    76    77    78    79;
    81    82    83    84    85    86    87    88    89;
    91    92    93    94    95    96    97    98    99;
</NUM>

<NUM otherdata> 1
<CHA otherchar> 'char' 'string'
```

Run **mytbl = tmt2struct('data.tmt')** to generate a structure *mytbl* with field *mytbl.tdata* being a 9 by 9 matrix as listed above. Then run **S = tmt2struct('test.tmt',mytbl)** to generate the structure *S* as given in Figure 2-1.

The *S.thist* is loaded from the [1 4 5] columns of the external *mytbl.tdata* field, i.e.,

```
S.thist = [
    11    14    15
    21    24    25
    31    34    35
    41    44    45
    51    54    55
    61    64    65
    71    74    75
    81    84    85
    91    94    95
];
```

Finally run **struct2tmt(S,'test_out.tmt')** to generate another TMT file *'test_out.tmt'* that is equivalent to the original *'test.tmt'* file but with external data *mytbl.tdata* built-in. The *'test_out.tmt'* is given as follows.

```
<NUM integer> 10;
<NUM number> -10.1;
<NUM col_vector> 1;
                 2;
                 3;
                 4;
                 5;
<NUM row_vector> 1 2 3 4 5;
<NUM matrix> 1 2;
             3 4;
<NUM thist> 11 14 15;
            21 24 25;
            31 34 35;
            41 44 45;
            51 54 55;
            61 64 65;
            71 74 75;
            81 84 85;
            91 94 95;
<CHA char> ' a string'
<CHA cell> 'string 1'
           'string 2'
<STR struct>
     <CHA name> 'name'
     <STR data>
          <NUM a> 1;
          <NUM b> 2;
     </STR>
</STR>
```

## TMTEDITOR

**TmtEditor** is developed to brower and edit TMT files. Details on TMTEDITOR is given in Appendix A.

# Other File Format

## ASCII Data Files

The AHBM toolbox supports common ASCII data file formats, such as space or tab delimited files (*.txt, .dat); comma delimited files (.csv); etc. Routines are developed to convert data among file formats.

## GDIF File Format

**General Data Interchange Format (GDIF)** is a self-documented ASCII format (.jif) with variable name, units, and description included within the file to record time-traces. The GDIF ASCII format can be converted into a binary form (.jib). The GDIF binary format can be accessed by the specialized programs developed by Jaycor, Inc.

## StdMat Data File

StdMat is a customized Matlab binary file (*.mat) format to record matrix data. Each variable (array) in the file is a structure with data saved column-wisely in a matrix. The variables should have the fields as given in Table 2-4.

**Table 2-4. Fields of a Variable in StdMat File**

| Field Name | Description |
|---|---|
| name | A string vector with each element being the name of one column of matrix data |
| label | A string vector with each element being the label (additional comments) of one column of matrix data |
| units | A string vector with each element being the units of one column of matrix data |
| val | Matrix data (saved column-wisely) |
| groupname | The name of the group under which the data is grouped |

StdMat file formats provides a common ground where complex matrix data (including time traces) can be saved and shared. It can be accessed by the I/O functions in Matlab and the I/O routines developed in AHBM toolbox.

## INI File

INI file is the window initialization file format (*.ini). INI files are mostly used for developing GUI applications.

# Data Conversion and I/O Routines

## List of Data Conversion and I/O Routines

| | |
|---|---|
| tmt2struct: | load a structure from tmtfile (and possibly a table file) |
| struct2tmt: | save structure to a tmtfile (and possibly a table file) |
| ini2struct: | read a window ini file and save the data as a struct |
| struct2ini: | save struct data into window ini file |
| mat2stdmat: | matrix to std structured format conversion |
| stdmat2csv: | save std structure format as a csv file |
| stdmat2jif: | save std structure format as a jif file |
| jif2stdmat2: | read a jif file in std structured format |
| load_ascii: | the counterpart of 'load filename -ascii' in standalone |

# tmt2struct

## SYNOPSIS

S = tmt2struct(tmtfile,TABLE)

## INPUTS

| | |
|---|---|
| Tmtfile: | Tagged Matlab Text filename |
| TABLE: | (optional) external structure referred from tmtfile |

## OUTPUT

| | |
|---|---|
| S: | the structure loaded from tmtfile |

## DESCRIPTION

TMT2STRUCT load a structure from tmtfile. If tmtfile also refers to external data

## EXAMPLES

First generate a tmtfile and a tablefile using struct2tmt

```
S.name = 'sample string'
S.data = rand(100,3);
struct2tmt(S,'test.tmt','test.table');
```

Read external data from tablefile 'test.table'

```
mydata = tmt2struct('test.table');
```

Read S from 'test.tmt' and mydata

```
S = tmt2struct('test.tmt',mydata);
```

## NOTE

## ROUTINES CALLED

A number of internal functions

## SEE ALSO

struct2tmt

# struct2tmt

## SYNTAX

struct2tmt(S,tmtfile,tablefile,option,desp);

## INPUT:

S: the structure to be output
tmtfile: Tagged Matlab Text filename
tablefile: (optional) the filename of an additional table file where very long data of txtfile is stored and cross-referred
option: (optional) 'replace' (default) or 'add'

## OUTPUT

none

## DESCRIPTION

STRUCT2TMT save a structure in a TMT file

## EXAMPLES

S.name = 'sample string'
S.data = rand(100,3);
struct2tmt(S, 'test.tmt'); will save structure S to test.tmt
struct2tmt(S,'test.tmt','test.table'); will save structure to 'test.tmt'

The S.data will be saved in 'test.table' with a <TAB ...> link created in 'test.tmt'

## NOTE

1. When tablefile is not input, all data will be saved in txtfile. When tablefile is input, all numeric data with size greater than 50 will be saved in the tablefile, and a cross-reference <TAB ...> will be added in the txtfile
2. Set option = 'replace' will overwrite txtfile or tablefile if they are already exist. Set option = 'add' will append to the existing files

## ROUTINES CALLED

A number of internal functions

## SEE ALSO

tmt2struct

# ini2struct

## SYNOPSIS

S = ini2struct(file);

## INPUTS

File: file name, the file should follow the above format the window ini file should follow the following convention

```
[section name]
varname1 = value1
varname2 = value2
```

currently, section name line is ignored value should be number, row vector, or a string

## OUTPUT

S: the structure loaded from an INI file

## DESCRIPTION

INI2STRUCT reads an INI file and saves the data as a structure

## EXAMPLES

First generate an INI file

```
S.dir1 = 'c:\';
S.data = [1 1 2 3];
struct2ini('try.ini',S);
```

Then read from the INI file

```
T = ini2struct('try.ini');
```

## NOTE

Only row vectors can be used as numerical value

## ROUTINES CALLED

none

## SEE ALSO

struct2ini

# struct2ini

## SYNOPSIS

struct2ini(file,S);

## INPUTS

File: file name, the file should follow the above format. The window INI file should follow the following convention

```
[section name]
varname1 = value1
varname2 = value2
```

Currently, section name line is ignored. Value should be number, row vector, or a string

S: structure to be output to the INI file

## OUTPUT

none

## DESCRIPTION

STRUCT2INI writes an INI file from a structure

## EXAMPLES

```
S.dir1 = 'c:\'
S.data = [1 1 2 3];
struct2ini('try.ini',S);
```

## NOTE

Only row vectors can be used as numerical input

## ROUTINES CALLED

none

## SEE ALSO

ini2struct

# mat2stdmat

## SYNOPSIS

stdmat = mat2stdmat(mat,name,label,units,groupname);

## INPUTS

mat: matrix data/ string data

names:{ncol} cell or a single string/cell corresponding to each column data. If a single string is used, name_icol will be set for each column data

label: {ncol} cell or a single string/cell to each column data. If a single string is used, label_icol will be set for each column data

units: {ncol} cell or a single string/cell corresponding to each column data. If a single string is used, same units will be added to each column data

groupname : (optional) a single string, indicates the groupname of the matlab data

## OUTPUT

stdmat: the standard structured mat data loaded from the file

## DESCRIPTION

MAT2STDMAT converts a column-wise matrix into standard structured matlab data (StdMat) file.

## EXAMPLES

```
V = rand(30,3);
stdV = mat2stdmat(V,{'V_1','V_2','V_3'},{'V_1','V_2','V_3'},...
{'m','m','m'})
```

## NOTE

## ROUTINES CALLED

A number of internal functions

## SEE ALSO

stdmat2csv, stdmat2jif

# stdmat2csv

## SYNOPSIS

stdmat2csv(csvfile,stdmat,option);;

## INPUT:

| | |
|---|---|
| csvfile: | name of the csv file, |
| stdmat: | data follows the standard structured mat format |
| option: | 'add' or 'replace' for adding to the file or rewrite the file. The default value for option is 'add' |

## OUTPUT:

A CSV file where the data will be saved row-wisely

## DESCRIPTION

STDMAT2CSV writes a CSV ASCII file from the standard structured matlab data.

## EXAMPLES

```
V = rand(30,3);
stdV = mat2stdmat(V,{'V_1','V_2','V_3'},{'V_1','V_2','V_3'},...
{'m','m','m'});
stdmat2csv('try.csv',stdV);
```

## NOTE

## ROUTINES CALLED

## SEE ALSO

stdmat2jif

# stdmat2jif

## SYNOPSIS

stdmat2jif(gdif,stdmat);

## INPUT:

gdif: name of the jif file, *.jif file extension will be added automatically
stdmat: structured mat data to be output

## OUTPUT:

A GDIF ASCII file

## DESCRIPTION

STDMAT2JIF writes a GDIF ASCII file from the standard structured matlab data.

## EXAMPLES

```
V = rand(30,3);
stdV = mat2stdmat(V,{'V_1','V_2','V_3'},{'V_1','V_2','V_3'},...
{'m','m','m'});
stdmat2jif('try.jif',stdV);
```

## NOTE

## ROUTINES CALLED

A number of internal functions

## SEE ALSO

stdmat2csv

# jif2stdmat

## SYNOPSIS

function DATA = jif2stdmat(gdif);

## INPUTS:

Gdif: name of the GDIF file,

## OUTPUT:

DATA: a structure contains StdMat structures as fields
.stdmat1
.stdmat2 ... etc

## DESCRIPTION

JIF2STDMAT reads a GDIF file and saves it in the structure DATA. Each field in DATA is a StdMat structure

## EXAMPLES

```
V = rand(30,3);
stdV = mat2stdmat(V,{'V_1','V_2','V_3'},{'V_1','V_2','V_3'},...
{'m','m','m'});
stdmat2jif('try.jif',stdV);
stdVin = jif2stdmat('try.jif')
```

## NOTE

## ROUTINES CALLED

A number of internal functions

## SEE ALSO

stdmat2jif

# load_ascii

## SYNTAX

[data,errormsg] = load_ascii(filename);

## INPUT:

filename: the ASCII data file name

## OUTPUT

data: data matrix loaded from the ascii file
errormsg: errormsg saves the error message if error is encountered in reading the file

## DESCRIPTION

LOAD_ASCII is the counterpart of 'load filename -ascii' in standalone applications. It reads the first line of the ASCII file to get the number of columns of and then fast reads the ASCII file

## EXAMPLES

## ROUTINES CALLED

## SEE ALSO

# 3. Rigid Body Routines

# Kinematics Routines

## List of Kinematics Routines

| | |
|---|---|
| eul2r: | Euler angles to rotation matrix conversion |
| r2eul: | Rotational matrix to Euler angles conversion |
| ep2r: | Euler parameters to rotation matrix conversion |
| r2ep : | Rotational matrix to Euler parameters conversion |
| r2_body_ang: | Body orientation (Euler) angles calculation from its rotation matrix |
| r2_jnt_ang : | Joint angle calculation from rotation matrices |

# eul2r

## SYNOPSIS

varargout = eul2r(eul,cnvt,opt)

## INPUTS

eul: euler angles (3x1)
cnvt: Convention for euler angles ('zxz', 'zyx')
opt: (optional) vector (7x1) deciding which terms to be calculated
opt(1): calcaulte R, saved as 3x3 matrix or a nx9 matrix
opt(2): dR/deul(m), saved as 9x3 matrix in Rij,m
opt(3): dR^2/deul(m)/deul(n), saved as 9x6 matrix in Rij,mn
opt(4): S1 (3x3 matrix), omegab = S1*deul/dt
opt(5): T, (3x3 matrix), deul/de = T*omegab
opt(6): dT/deul(m), saved as 9x3 matrix in Tij,m
opt(7): S2 (3x3 matrix), as in the equation
S1*deul^2/dt^2+S2*[de1*de2;de1*de3;de2*de3];

## OUTPUT

varargout: matrices output dependent on opt

## DESCRIPTION

EUL2R performs basic calculations regarding Euler angles to rotation matrix conversion such as calculating the rotational matrix R, its derivatives dR/de(m), dR^2/de(m)/de(n), the derivative to angular velocity matrix S, its inverse matrix T, its deriviative dT/de(m), and deriviative to angylar acceleration matrix S2

## EXAMPLES

example # 1: calculate only R matrix

```
eul = [3 1 2];
R = eul2r(eul,'zxz');
```

example # 2: calculate; differential matrices; velocity matrix, etc

```
[R,dRdm,dRdmn,T,dTdm] = eul2r(eul,'zyx',[1 1 1 1 1]');
[T,dTdm] = eul2r(eul,'zyx',[0 0 0 1 1]);
```

example # 3: acceleration conversion matrix

```
S2 = eul2r(eul,'zyx',[0 0 0 0 0 0 1]);
```

example # 4: time series of rotation matrix

```
eul = [ 3 1 2; 2 1 1; 1 0 3; 0 0 pi/2];
R = eul2r(eul,'zxz');
```

## NOTE

1. Using *reshape(dRdm(:,i),3,3)* to restore dRdm as a 3x3 matrix

2. when only R is calculated, vectorized programming is supported; R can be saved as a 3x3 matrix or a nx9 representing different frames
3. trailing zeros in opt can be neglected

## ROUTINES CALLED

none

## SEE ALSO

r2eul

# r2eul

## SYNOPSIS

eul = r2eul(R,cnvt,opt)

## INPUTS

R: Rotational matrix R = [i,j,k]; (3x3 or nx9)
cnvt: Convention for euler angles ('zxz', 'zyx')
opt: options determining the default range of theta (default =1)
=1, theta = [0,pi] for ZXZ and [-pi/2 pi/2] for ZYX
=2, theta = [-pi,0] for ZXZ and [-pi,-pi/2] and [pi/2,pi] for ZYX

## OUTPUT

eul: calculated Euler angles

## DESCRIPTION

R2EUL calculates Euler angles from a rotation matrix (3x3) or a series of rotation matrices (nx9)

## EXAMPLES

```
eul = [3 4 2];
R = eul2r(eul,'zxz');
eul1 = r2eul(R,'zxz');
eul2 = r2eul(R,'zxz');
```

## NOTE

A small number is used to judge if gimble locking occurs, the number del=1e-5

## ROUTINES CALLED

none

## SEE ALSO

eul2r

# ep2r

## SYNOPSIS

varargout = ep2r(ep,opt)

## INPUTS

ep: uler parameters (4x1)
opt: etermine whether to calculate each term (5x1)
opt(1)=1: calculate R , saved as 3x3 matrix
opt(2)=1: calculate dR/de(m) , saved as 9x4 matrix in Rij,m
opt(3)=1: calculate dR^2/de(m)/de(n), saved as 9x10 matrix in Rij,mn
opt(4)=1: calculate T (4x3) as in de= T*w_b
opt(5)=1: calculate dT/de(m) (saved as Tij,m 12x4)

## OUTPUT

varargout: matrices output dependent on opt

## DESCRIPTION

EP2R: performs basic calculations regarding Euler parameters to rotation matrix conversion such as calculating the rotational matrix R, its derivatives dR/de(m), dR^2/de(m)/de(n), the derivative to angular velocity matrix T, and its derivative dT/de(m)

## EXAMPLES

example # 1: calculate only R matrix

```
ep = [3 1 2 10];
R = ep2r(ep);
```

example # 2: calculate R matrix; differential matrices, etc

```
[R,dRdm,dRdmn,T,dTdm] = ep2r(ep,[1 1 1 1 1]');
[T,dTdm] = ep2r(ep,[0 0 0 1 1]);
```

## NOTE

1. Default of option calculates only R, opt = [1 0 0 0 0];
2. Trailing zeros in opt can be neglected

## ROUTINES CALLED

none

## SEE ALSO

r2ep

# r2ep

## SYNOPSIS

ep = r2ep(R)

## INPUTS

R: rotational matrix (3x3)

## OUTPUT

ep: euler parameters (4x1)

## DESCRIPTION

R2EP calculates the Euler parameters from a rotational matrix

## EXAMPLES

```
eul = [3 4 2];
R1 = eul2r(eul,'zxz');
ep = r2ep(R1);
R2 = ep2r(ep);
```

## NOTE

## ROUTINES CALLED

none

## SEE ALSO

ep2r

# r2_body_ang

## SYNOPSIS

ang = r2_body_ang(R,type,ang0);

## INPUTS

R: rotational matrix (3x3)
type: convention ('zxz','zyx')
ang0: Initial euler angles (usually the value of previous time step)

## OUTPUT

ang: body orientation (Euler) angles (3x1),

## DESCRIPTION

R2_BODY_ANG calculates the Euler angles of a given body relative to the default coordinate system. If ang0 is also given, the ang will start from ang0. This enables the range of Euler angles be extended beyond [-pi pi] for tumbling motion;

## EXAMPLES

```
eul = [3 4 2];
R = eul2r(eul,'zxz');
ang1 = r2_body_ang(R,'zxz');
ang2 = r2_body_ang(R,'zxz',[2.5 3.5 1.9]);
```

notice in the example, ang2 is exactly same as eul; while ang1 is not

## NOTE

If ang0 is given, the program will automatically

- Eliminate the jump due to degeneracy
- Add or remove 2*n*pi to make solution continuous

## ROUTINES CALLED

r2eul

## SEE ALSO

r2_jnt_ang

# r2_jnt_ang

## SYNOPSIS

jang = r2_jnt_ang(R1,R2,type,jang0);

## INPUTS

R1: rotational matrix for 1st segment
R2: rotational matrix for 2nd segment
type: type of joints
jang0: initial joint angles (usually the value of previous time step)

## OUTPUT

jang: calculated joint angles

## DESCRIPTION

R2_JNT_ANG calculates the joint angles given two rotational matrices for the two segments connecting the joint. If jang0 is also given, the jang will start from jang0. This extends the range of joint angles beyond [-pi pi] and allows the tracking of tumbling motion

## EXAMPLES

```
eul1 = [3 4 2];
eul2 = [3 4 2];
R1 = eul2r(eul1,'zxz');
R2 = eul2r(eul2,'zxz');
jang1 = r2_jnt_ang(R1,R2,'zxz');
jang2 = r2_jnt_ang(R1,R2,'zxz',[0 2*pi 0]);
```

## NOTE

Currently, zxz, zyx, pin, null2d, pin3d joints are supported

## ROUTINES CALLED

r2eul

## SEE ALSO

r2_body_ang

# Forward Dynamics Routines

## List of Forward Dynamics Routines

| | |
|---|---|
| fwd_simu | main setup routine for forward dynamics analysis |
| fwd_integrator | ode integrator setup routine |
| fwd_equation | forward dynamics ode equation routine |
| projection | constraint projection routine |
| cnstode45 | ode 45 non-stiff solve for constrained system |
| cnstode15s | ode 15 stiff solve for constrained system |
| cnstode23s | ode 23 stiff solve for constrained system |
| jnt_cnst | G, g1g2 and g due to joint constraints |
| jnt_cnst_euler | G, g1g2 and g due to Euler joint constraints |
| jnt_cnst_pin | G, g1g2 and g due to 3d pin joint constraints |
| jnt_cnst_pin2d | G, g1g2 and g due to 2d pin joint constraints |
| jnt_cnst_null2d-- | G, g1g2 and g due to 2d null joint constraints |
| jnt_react | joint reaction force calculation |
| jnt_react_euler | joint reaction force due to an Euler joint |
| jnt_react_pin | joint reaction force due to a 3d pin joint |
| jnt_react_pin2d | joint reaction force due to a 2d pin joint |
| jnt_react_null2d | joint reaction force due to a 2d null joint |
| spring_force | calculate spring force |
| damper_foce | calculate damping force |
| stop_force | calculate joint soft stop force |
| ddRxppl | calculate vR2 = Rij,mn*dpm*dpn*lj |
| dRxl | calculate R1l = Rij,m*lj |
| dTxpv | calculate the vector vR2 = Tlm,n*dpn*vm |

# fwd_simu

## SYNOPSIS

t_cpu = fwd_simu(job_file, choice);

## INPUTS

job_file: file keep job information (include the system to use)
choice: select the task to perform
input': read in all job, model and force files
'initialization': check default, error etc, setup geometry
'run': run simulation, sorting data ...
'all': perform all the preceding tasks (default)

## OUTPUT

t_cpu: cpu time for the task

## GLOBAL:

| | |
|---|---|
| SYSTEM | system description structure |
| BODY | body description structures |
| JOINT | joint description structures |
| JOB | job description structure |
| EXF | external force structures |

## DESCRIPTION

FWD_SIMU set up a forward dynamics model by

- read job and ahm input files
- verify the input data are correct
- setup the initial configuration
- setup the geometry patch
- run integration

## EXAMPLES

## NOTE

## ROUTINES CALLED

A number of internal routines
fwd_integrator

## SEE ALSO

# fwd_integrator

## SYNOPSIS

[time,Y,STAT] = fwd_integrator(options);

## INPUTS

| | |
|---|---|
| options: | extra options for the integrator (refers to odeset) |

## OUTPUT

| | |
|---|---|
| time: | time vector when solution is outputed |
| Y: | position and velocity solution |
| STAT: | solver statistics |

## GLOBAL:

| | |
|---|---|
| SYSTEM | system description structure |
| BODY | body description structures |
| JOINT | joint description structures |
| JOB | job description structure |
| EXF | external force structures |

## DESCRIPTION

FWD_INTEGRATOR sets up the ode integrator for forward dynamics problem, performs the integration, and saves the results in result and restart files

## EXAMPLES

## NOTE

## ROUTINES CALLED

fwd_equation

## SEE ALSO

# fwd_equation

## SYNOPSIS

varargout = fwd_equation(t,y,flag,varargin);

## INPUTS

t: time
y: [p,v]' (variable of the 1st order ODE system)
flag: flag of task to be performed
- '': (default) evaluate y' = f(y)
- 'update': update solution after a successful step
- 'call_proj': call projection routine for position and velocity constraints
- 'proj_1': called from projection routine to calculate M, G and gi
- 'proj_2': called from projection routine to calculate g

varargin:other input arguments to be passed on, including
- isproj: =1 do project; =0 do not project
- isupdate: =1 update solution after a successful step, =0 do not

## OUTPUT

varargout: variable outputs depend on the flag

## DESCRIPTION

FWD_EQUATION setup the forward dynamics equations for ODE solver

## EXAMPLES

## NOTE

## ROUTINES CALLED

projection, cnstode45, cnstode15s, cnstode23s

## SEE ALSO

# projection

## SYNOPSIS

yproj = projection(odefile,t,y,NP,NV,NL);

## INPUT:

| | |
|---|---|
| odefile: | filename of the ode and constraint formulation |
| t: | current time |
| y: | original converged solution |
| NP: | number of position degrees of freedom |
| NV: | number of velocity degrees of freedom |
| NL: | number of constraints equations |

## OUTPUT:

| | |
|---|---|
| yproj: | projected solutions |

## OUTPUT

| | |
|---|---|
| time: | time vector when solution is outputed |
| Y: | position and velocity solution |
| STAT: | solver statistics |

## DESCRIPTION

PROJECTION projects the approximation solution back to the position and velocity constraint manifolds

## EXAMPLES

## NOTE

## ROUTINES CALLED

cnstode45, cnstode15s, cnstode23s

## SEE ALSO

# cnstode45

## SYNOPSIS

[tout,yout,varargout] = ode15s(odefile,tspan,y0,options,varargin)

## INPUTS

refer to ode45

## OUTPUT

refer to ode45

## DESCRIPTION

CNSTODE45 is the extension of ODE45 non-stiff ode solver to include position and velocity constraints

## EXAMPLES

## NOTE

## ROUTINES CALLED

none

## SEE ALSO

cnstode15s; cnstode23s

# cnstode15s

## SYNOPSIS

[tout,yout,varargout] = ode15s(odefile,tspan,y0,options,varargin)

## INPUTS

refer to ode15s

## OUTPUT

refer to ode15s

## DESCRIPTION

CNSTODE15S is the extension of ODE15S stiff ode solver to include position and velocity constraints

## EXAMPLES

## NOTE

## ROUTINES CALLED

none

## SEE ALSO

cnstode45; cnstode23s

# cnstode23s

## SYNOPSIS

[tout,yout,varargout] = ode23s(odefile,tspan,y0,options,varargin)

## INPUTS

refer to ode23s

## OUTPUT

refer to ode23s

## DESCRIPTION

CNSTODE23S is the extension of ODE23S stiff ode solver to include position and velocity constraints

## EXAMPLES

## NOTE

## ROUTINES CALLED

none

## SEE ALSO

cnstode45; cnstode15s

# jnt_cnst

## SYNOPSIS

varargout = jnt_cnst(t,P,V,body1,body2,jnt,opt);

## INPUTS

t: current time
P: position vector
V: velocity vector
body1: structure data for inboard body
body2: structure data for outboard body
jnt: structure data for the joint
opt: option of calculation
1. calculate the contribution to g
2. calculate the contribution to G
3. calculate the contribution to G and gagb

## OUTPUT

varargout: output depends on opt

## DESCRIPTION

JNT_CNST calculates the contribution of the joint constraints to G, g1g2 and g

## EXAMPLES

## NOTE

## ROUTINES CALLED

Joint constraint routines for various joints

## SEE ALSO

# jnt_cnst_euler

## SYNOPSIS

varargout = jnt_cnst_euler(t,P,V,body1,body2,jnt,opt);

## INPUTS

t: current time
P: position vector
V: velocity vector
body1: structure data for inboard body
body2: structure data for outboard body
jnt: structure data for the joint
opt: option of calculation
1. calculate the contribution to g
2. calculate the contribution to G
3. calculate the contribution to G and gagb

## OUTPUT

varargout: output depends on opt

## DESCRIPTION

JNT_EULER_CNST calculates the contribution of an Euler joint to G, g1g2 and g

## EXAMPLES

## NOTE

An Euler joint only involves position constraint. When the joint is connected to the ground, the position should equal to the designated position. Otherwise, the two neighboring bodies are connected at the joint

R*l - Og = 0;
R1*l1 - R2*l2 = 0;

## ROUTINES CALLED

ddRxppl, dTxpv, drxl

## SEE ALSO

# jnt_cnst_pin

## SYNOPSIS

varargout = jnt_cnst_pin(t,P,V,body1,body2,jnt,opt);

## INPUTS

t: current time
P: position vector
V: velocity vector
body1: structure data for inboard body
body2: structure data for outboard body
jnt: structure data for the joint
opt: option of calculation
1. calculate the contribution to g
2. calculate the contribution to G
3. calculate the contribution to G and gagb

## OUTPUT

varargout: output depends on opt

## DESCRIPTION

JNT_CNST_PIN calculates the contribution of a 3D pin joint to G, g1g2 and g

## EXAMPLES

## NOTE

A pin joint involves position constraint (as in an Euler joint) pluses two rotational constraints

## ROUTINES CALLED

ddRxppl, dTxpv, drxl; joint_cnst_euler

## SEE ALSO

# jnt_cnst_pin2d

## SYNOPSIS

varargout = jnt_cnst_pin(t,P,V,body1,body2,jnt,opt);

## INPUTS

t: current time
P: position vector
V: velocity vector
body1: structure data for inboard body
body2: structure data for outboard body
jnt: structure data for the joint
opt: option of calculation
1. calculate the contribution to g
2. calculate the contribution to G
3. calculate the contribution to G and gagb

## OUTPUT

varargout: output depends on opt

## DESCRIPTION

JNT_CNST_PIN2D calculates the contribution of a 2D pin joint to G, g1g2 and g

## EXAMPLES

## NOTE

A pin2d joint only involves position constraint. When the joint is connected to the ground, the position should equal to the designated position, otherwise, the two neighboring bodies are connected at the joint

R*l - Og = 0;
R1*l1 - R2*l2 = 0;

## ROUTINES CALLED

ddRxppl, dTxpv, drxl

## SEE ALSO

# jnt_cnst_null2d

## SYNOPSIS

varargout = jnt_cnst_null2d(t,P,V,body1,body2,jnt,opt);

## INPUTS

t: current time
P: position vector
V: velocity vector
body1: structure data for inboard body
body2: structure data for outboard body
jnt: structure data for the joint
opt: option of calculation
1. calculate the contribution to g
2. calculate the contribution to G
3. calculate the contribution to G and gagb

## OUTPUT

varargout: output depends on opt

## DESCRIPTION

JNT_CNST_PIN2D calculates the contribution of a 2D null joint to G, g1g2 and g

## EXAMPLES

## NOTE

No constraint is involved for a 2D null joint

## ROUTINES CALLED

## SEE ALSO

# jnt_reaction

## SYNOPSIS

f = jnt_reaction(t,P,V,body1,body2,joint);

## INPUTS

t: current time
P: position vector
V: velocity vector
body1: structure data for inboard body
body2: structure data for outboard body
joint: structure data for the joint

## OUTPUT

f: calculated reaction force

## DESCRIPTION

JNT_REACTION calculates the joint reaction forces due to joint spring, damper or joint soft stop

## EXAMPLES

## NOTE

## ROUTINES CALLED

Joint reaction force routines for various joints

## SEE ALSO

# jnt_react_euler

## SYNOPSIS

f = jnt_react_euler(t,P,V,body1,body2,jnt,opt);

## INPUTS

t: current time
P: position vector
V: velocity vector
body1: structure data for inboard body
body2: structure data for outboard body
joint: structure data for the joint

## OUTPUT

f: calculated reaction force

## DESCRIPTION

JNT_REACT_CNST calculates the Euler joint reaction forces due to joint spring, damper or joint soft stop

## EXAMPLES

## NOTE

An Euler joint has three rotational degree of freedom ground can only be inboard

## ROUTINES CALLED

r2_jnt_ang; spring_force; damper_force; stop_force

## SEE ALSO

# jnt_react_pin

## SYNOPSIS

f = jnt_react_pin(t,P,V,body1,body2,jnt,opt);

## INPUTS

t: current time
P: position vector
V: velocity vector
body1: structure data for inboard body
body2: structure data for outboard body
joint: structure data for the joint

## OUTPUT

f: calculated reaction force

## DESCRIPTION

JNT_REACT_PIN calculates the 3D pin joint reaction forces due to joint spring, damper or joint soft stop

## EXAMPLES

## NOTE

## ROUTINES CALLED

r2_jnt_ang; spring_force; damper_force; stop_force

## SEE ALSO

# jnt_react_pin2d

## SYNOPSIS

f = jnt_react_pin2d(t,P,V,body1,body2,jnt,opt);

## INPUTS

t: current time
P: position vector
V: velocity vector
body1: structure data for inboard body
body2: structure data for outboard body
joint: structure data for the joint

## OUTPUT

f: calculated reaction force

## DESCRIPTION

JNT_REACT_PIN2D calculates the 2D pin joint reaction forces due to joint spring, damper or joint soft stop

## EXAMPLES

## NOTE

## ROUTINES CALLED

r2_jnt_ang; spring_force; damper_force; stop_force

## SEE ALSO

# jnt_react_null2d

## SYNOPSIS

varargout = jnt_react_null2d(t,P,V,body1,body2,jnt,opt);

## INPUTS

t: current time
P: position vector
V: velocity vector
body1: structure data for inboard body
body2: structure data for outboard body
joint: structure data for the joint

## OUTPUT

f: calculated reaction force

## DESCRIPTION

JNT_REACT_NULL2D calculates the 2D null joint reaction forces due to joint spring, damper or joint soft stop

## EXAMPLES

## NOTE

## ROUTINES CALLED

r2_jnt_ang; spring_force; damper_force; stop_force

## SEE ALSO

# spring_force

## SYNOPSIS

F = spring_force(type,prop,d);

## INPUTS

type: type of spring (nspring x 1) cell
'linear': linear spring represented by k
'tabular': nonlinear spring represented by tabular form
prop : spring properties data cell
'linear': k
'tabular': [d(:) F(:)]
d: joint relative displacement (nspring x 1), d should be in ascending order

## OUTPUT

F: spring force (nspring x 1)

## DESCRIPTION

SPRING_FORCE calculates the spring forces according to the type and properties of the spring

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

damper_force

# ddRxppl

## SYNOPSIS

vR2 = ddRxppl(dRdmn,dp,l)

## INPUTS

| | |
|---|---|
| dRdmn: | dR^2/dp(m)/dp(n) |
| l: | postion vector |
| dp: | dp/dt |

## OUTPUT

| | |
|---|---|
| vR2: | resultant vector |

## DESCRIPTION

ddRxppl calculates the vector vR2 = Rij,mn*dpm*dpn*lj

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

# dRxl

## SYNOPSIS

R1l = drxl(dRdm,l)

## INPUTS

| | |
|---|---|
| dRdm: | dR/dp(m) |
| l: | postion vector |

## OUTPUT

| | |
|---|---|
| Rl1: | calculated matrix R1l; 3x3 for Euler angles; 3x4 for Euler parameters |

## DESCRIPTION

dRxl calculates the matrix R1l = Rij,m*lj

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

# dTxpv

## SYNOPSIS

vT = dTxpv(dTdm,dp,v)

## INPUTS

| | |
|---|---|
| dTdm: | as in pdot = dTdm *v, see zxz2t |
| dp: | dp/dt |
| v: | segment angular velocity |

## OUTPUT

| | |
|---|---|
| vT: | calculated vector |

## DESCRIPTION

dTxpv calculates the vector vR2 = Tlm,n*dpn*vm

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

# Inverse Dynamics Routines

## List of Inverse Dynamics Routines

| | |
|---|---|
| inv_analysis | main setup routine for inverse dynamics analysis |
| inv_kinematics | kinematics calculation |
| inv_dynamics | inverse dynamics calculation |

# inv_analysis

## SYNOPSIS

[SYSTEM,JOB,BODY,JOINT,EXF] = inv_analysis(jobfile);

## INPUTS

jobfile: file keep job information (include the model system to use)

## OUTPUT

| | |
|---|---|
| SYSTEM | system description structure |
| BODY | body description structures |
| JOINT | joint description structures |
| JOB | job description structure |
| EXF | external force structures |

## DESCRIPTION

INV_ANALYSIS performs the following tasks:

1. verify and read in the job, model and data
2. kinematics analysis
   - 2.1 filter the kinematics data (body, joint)
   - 2.2 calculate linear velocity and acceleration
   - 2.3 calculate body and joint angles
   - 2.4 calculate angular velocity and acceleration
   - 2.5 calculate joint angle
3. dynamics analysis
   - 3.1 Calculate the joint forces and torques in gloval frame
   - 3.2 Convert the force and torque into body local frame
   - 3.3 Convert the force and torque into anatomical frame
4. Calculate additional energetic quantities
5. Output results to files

## EXAMPLES

## NOTE

## ROUTINES CALLED

A number of internal routines
inv_kinematics,
inv_dynamics
math function; i/o functions, etc

## SEE ALSO

# inv_kinematics

## SYNOPSIS

[BODY,JOINT] = inv_kinematics(SYSTEM,JOB,BODY,JOINT);

## INPUTS

| | |
|---|---|
| SYSTEM: | SYSTEM definition structure |
| JOB: | JOB definition structure |
| BODY: | BODY definition structure |
| JOINT: | JOINT definition Structure |

## OUTPUT

| | |
|---|---|
| BODY: | BODY definition structure, with updated kinematics information |
| JOINT: | JOINT definition structure, with updated kinematics information |

## DESCRIPTION

INV_KINEMATICS performs the following tasks:

1. filter the kinematics data (body, joint)
2. calculate linear velocity and acceleration
3. calculate body and joint angles
4. calculate angular velocity and acceleration
5. calculate joint angle

## EXAMPLES

## NOTE

## ROUTINES CALLED

| | |
|---|---|
| matfiltfilt: | Butterworth filtering of matrix data |
| dxdt: | derivative sof uniformly spaced data |
| r2_body_ang: | body orientation (Euler) angle calculation |
| eul2r: | euler angle to rotation matrix conversion |

## SEE ALSO

inv_dynamics

# inv_dynamics

## SYNOPSIS

JOINT = inv_dynamics(SYSTEM,JOB,BODY,JOINT,EXF);

## INPUTS

| | |
|---|---|
| SYSTEM: | SYSTEM definition structure |
| JOB: | JOB definition structure |
| BODY: | BODY definition structure |
| JOINT: | JOINT definition Structure |
| EXF: | External force data structure |

## OUTPUT

| | |
|---|---|
| JOINT: | JOINT definition structure, with updated dynamics information |

## DESCRIPTION

INV_DYNAMICS performs the following tasks:

1. calculate the joint forces and torques in the global frame
2. convert the force and torque into an anatomical frame

## EXAMPLES

## NOTE:

This routine works for an open-loop (tree) model, where a body can have more than one proximal joints, but only one distal joints

## ROUTINES CALLED

## SEE ALSO

inv_kinematics

# 4. Graphical Routines

# Graphical Objects Routines

## List for graphical objects Routines

Create graphical objects

| | |
|---|---|
| gen_patch_block: | generate a 3d block patch |
| gen_patch_cylinder: | generate a 3d cylindrical patch |
| gen_patch_sphere: | generate a 3d spherical patch |
| gen_patch_arrow: | generate an arrow patch |
| gen_patch_spring: | generate a spring patch |
| gen_patch_ground: | generate a patch representing the ground |
| read_patch_asc: | read a patch from an ASCII ASC file |
| read_patch_xix: | read a patch from an ASCII XIX file |

Manipulate of graphical objects

| | |
|---|---|
| affine_patch: | perform affine transformation of a patch |
| scale_patch: | scale a patch |
| add_patch_prop: | add additional graphical properties to a patch |

# gen_patch_block

## SYNOPSIS

p = gen_patch_block(l,m,n,varargin)

## INPUTS

| | |
|---|---|
| l: | number of x elements |
| m: | number of y elements |
| n: | number of z elements |
| varargin: | parameter/value pairs to specify additional properties of the patch |

## OUTPUT

| | |
|---|---|
| p: | geometrical patch object |

## DESCRIPTION

GEN_PATCH_BLOCK generates a 3D block object with unit length in all the x, y, and z directions. The center of the block is located at the origin.

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

# gen_patch_cylinder

## SYNOPSIS

p = gen_patch_cylinder(m,n,varargin)

## INPUTS

| | |
|---|---|
| m: | an even number of elements along circumference (default = 20) |
| n: | an even number of elements in longitudinal direction (default = 20) |
| varargin: | parameter/value pairs to specify additional properties of the spring |

## OUTPUT

| | |
|---|---|
| p: | geometrical cylinder object |

## DESCRIPTION

GEN_PATCH_CYLINDER generates a cylindrical patch object of unit diameter and unit length and located at the origin and aligned in the z direction

## EXAMPLES

## NOTE

## ROUTINES CALLED

add_patch_prop

## SEE ALSO

# gen_patch_sphere

## SYNOPSIS

p = gen_patch_sphere(n,varargin)

## INPUTS

| | |
|---|---|
| n: | an even number of elements (default = 20) |
| varargin: | parameter/value pairs to specify additional properties of the sphere |

## OUTPUT

| | |
|---|---|
| p: | geometrical spherical object |

## DESCRIPTION

GEN_PATCH_SPHERE generates a spherical patch object of unit diameter with its center located at the origin of the reference system

## EXAMPLES

## NOTE

## ROUTINES CALLED

add_patch_prop

## SEE ALSO

# gen_patch_arrow

## SYNOPSIS

p = gen_patch_arrow(P1,P2,lHead,wHead,wTail,varargin)

## INPUTS

| | |
|---|---|
| P1: | coordinates of the end of the arrow |
| P2: | coordinates of the tip of the arrow |
| lHead: | ratio of head length |
| wHead: | ratio of head width |
| wTail: | ratio of tail width |
| varargin: | parameter/value pairs to specify additional properties of the arrow |

## OUTPUT

| | |
|---|---|
| p: | geometrical arrow object |

## DESCRIPTION

GEN_PATCH_ARROW generates a 3D geometrical object representing an arrow.

## EXAMPLES

## NOTE

## ROUTINES CALLED

add_patch_prop

## SEE ALSO

# gen_patch_spring

## SYNOPSIS

p = gen_patch_spring(P1,P2,m,w,width,varargin)

## INPUTS

| | |
|---|---|
| P1: | coordinates of starting point |
| P2: | coordinates of ending point |
| m: | number of rings in the spring |
| w: | width of the spring |
| varargin: | parameter/value pairs to specify additional properties of the spring |

## OUTPUT

| | |
|---|---|
| p: | geometrical spring object |

## DESCRIPTION

GEN_PATCH_SPRING generate a 3D geometrical object representing a spring.

## EXAMPLES

## NOTE

## ROUTINES CALLED

add_patch_prop

## SEE ALSO

# gen_patch_ground

## SYNOPSIS

p = gen_patch_ground(m,n,color1,color2,varargin)

## INPUTS

| | |
|---|---|
| m: | number of checked squares in x direction |
| n: | number of checked squares in y direction |
| color1: | color one of checked squares, default=[0.2 0.2 0.2] |
| color2: | color two of checked squares, default=[0 0 0] |
| varargin: | parameter/value pairs to specify additional properties of the ground |

## OUTPUT

| | |
|---|---|
| p: | geometrical ground object |

## DESCRIPTION

GEN_PATCH_GROUND generates a graphical patch object representing the ground. The ground is represented by checked interlacing squares. The patch is in XY plane with unit length in X and Y direction. The center is at the origin of the reference frame

## EXAMPLES

## NOTE

## ROUTINES CALLED

add_patch_prop; alias2rgb

## SEE ALSO

# read_patch_asc

## SYNOPSIS

asc = read_patch_asc(ascfile);

## INPUTS

ascfile: asc path data file name

## OUTPUT

Asc: geometrical patch structure with the following fields
Vertices: coordinates of geometrical nodes
Faces: node connectivity matrix
VertexNormals: (optional) normal at the nodes (for graphical rendering)

## DESCRIPTION

READ_PATCH_ASC reads in a geometrical patch defined in an ASCII ASC file

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

read_patch_xix

# read_patch_xix

## SYNOPSIS

xix = read_patch_xix(xixfile);

## INPUTS

xixfile: xix data file name

## OUTPUT

xix: geometrical patch structure with the following fields
Vertices: coordinates of geometrical nodes
Faces: node connectivity matrix
VertexNormals: (optional) normal at the nodes (for graphical rendering)

## DESCRIPTION

READ_PATCH_XIX reads in a geometrical patch defined in an ASCII XIX file

## EXAMPLES

NOTE

FORMAT of an xix file:
line 1: comment
line 2: NDIM
line 3: is_std_ix, node_per_face
line 4: nVertices, nFaces
one comment line
vertices coordinates
one comment line
IX data
Normal (optional)
node normal data
CData (optional)
FaceVerticeCData
FaceColor (optional)
face color
EdgeColor (optional)
edge color

## ROUTINES CALLED

## SEE ALSO

read_patch_asc

# affine_patch

## SYNOPSIS

pa = affine_patch(p,tran,R)

## INPUTS

p: geometrical patch object (usually aligned along the default coordinate system)
tran: translation along the x, y, z axes
R: rotational matrix representing orientation of the patch in the coordinate system

## OUTPUT

pa: geometrical patch object after affine transformation

## DESCRIPTION

AFFINE_PATCH performs an affine transformation of a geometrical patch

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

# scale_patch

## SYNOPSIS

ps = scale_patch(p,scale)

## INPUTS

p: geometrical patch object (usually aligned along the default coordinate system)
scale: scaling factor of the patch in x,y,z axes

## OUTPUT

ps: scaled patch

## DESCRIPTION

SCALE_PATCH scales a geometrical patch

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

# add_patch_prop

## SYNOPSIS

newP = add_patch_prop(oldP,varargin)

## INPUTS

| | |
|---|---|
| oldP: | old geometrical patch object |
| varargin: | parameter/value pairs to specify additional properties of the arrow |

## OUTPUT

| | |
|---|---|
| newP: | new geometrical patch object |

## DESCRIPTION

ADD_PATCH_PROP adds/modifies parameter/value pairs of a geometrical patch object

## EXAMPLES

## NOTE

Currently the following parameters are supported

EdgeColor
FaceColor
LineStyle
LineWidth

## ROUTINES CALLED

## SEE ALSO

# User Interface Routines

## List of User Interface Routines

| | |
|---|---|
| geticoncdata: | read from an icon file the cdata (color map) |
| seticoncdata: | set cdata on a toolbar button |
| show_btn_ctxMenu: | associate an context menu to a toolbar button |
| enableiconcdata: | enable or disable a toolbar button |
| msgOutput: | message output routine |
| filterUI: | update filter type in a filter popup menu |
| axis2fig: | copy and re-scale a axis onto a figure |
| setpopupvalue: | set the value of a popup to match a given string |

# geticoncdata

## SYNOPSIS

cdata = geticoncdata(iconfile,idx,bgcolor);;

## INPUTS

| | |
|---|---|
| iconfile: | name of a icon file |
| idx: | (default=1) the number of icon in the icon file |
| bgcolor: | the bg color to set as transparent |

## OUTPUT

| | |
|---|---|
| cdata: | RGB color data matrix of the icon |

## DESCRIPTION

GETICONCDATA reads from an icon file and save the icon as cdata. If bgcolor is provided, it also attempts to save the bgcolor as NaN. When used with seticoncdata, bgcolor will be displayed transparent

## EXAMPLES

## NOTE

The program can be modified to include alpha data (transparency)

## ROUTINES CALLED

## SEE ALSO

# seticoncdata

## SYNOPSIS

seticoncdata(h,Cdata);

## INPUTS

| | |
|---|---|
| h: | handle of the obj (pushbutton, etc) |
| Cdata: | n x m x 3 color data |

## OUTPUT

| | |
|---|---|
| cdata: | RGB color data matrix of the icon |

## DESCRIPTION

SETICONCDATA sets the CData on a UI (pushbutton etc). All NaN components will be displayed as the UI background color (looks like transparent)

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

# show_btn_ctxMenu

## SYNOPSIS

show_btn_ctxMenu;

## INPUTS

none

## OUTPUT

none

## DESCRIPTION

SHOW_BTN_CTXMENU displays context menu associated with a tool button. The handle of the tool button should be saved as the *userdata* of the button and the *enable* of the tool buttonn should be set as *'inactive'* the *buttondownfcn* of the button should be set as *'show_btn_ctxMenu'*

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

# enableiconcdata

## SYNOPSIS

enableiconcdata(hbtn,option);

## INPUTS

| | |
|---|---|
| hbtn: | handle of the obj (pushbutton, etc) (may be a vector) |
| option: | 'enable' or 'disable' |

## OUTPUT

| | |
|---|---|
| cdata: | RGB color data matrix of the icon |

## DESCRIPTION

enableiconcdata: enable or disable a tool button

## EXAMPLES

## NOTE

The use of multiple handles (hbtn being a vector) is supported

## ROUTINES CALLED

## SEE ALSO

# msgOutput

## SYNOPSIS

msgOutput(msg)

## INPUTS

msg: a string or a cell or strings (the message)

## OUTPUT

none

## DESCRIPTION

MSGOUTPUT outputs the message in the *msg* string to a command window, a message GUI window and/or a message file

## EXAMPLES

example one -- output message to command window

```
msgOutput('message to command window');
```

example two -- output message to msgwindow and save in a message file (tmp.msg)

```
close all; set(gcf,'unit','pixels')
h = uicontrol('style','listbox','tag','MsgWindow','pos',[10 10 200 100],'max',100);
setappdata(h,'msgFile','tmp.msg');
msgOutput({'example of msg output','also check the tmp.msg file'});
```

## NOTE

1. msgOutput first look for a msgwindow with a the tag of 'MsgWindow' (case senstive) if the msgwindow is not present, the msg will be output to the command window; otherwise the message will be added to the message window.
2. the maximum number of lines of message can be specified by setting the 'max' property of the UI control of the message window
3. the msg will be save as the appdata 'MSG' in msg
4. if appdata 'msgFile' is present in the message window, the msg will aslo be saved in the file

## ROUTINES CALLED

## SEE ALSO

# filterUI

## SYNOPSIS

filterUI(h,type);

## INPUTS

h: the filter UI handle (a popup menu);
type: string of the type of filter

## OUTPUT

none

## DESCRIPTION

filterUI updates the types of filter displayed in a popup menu and automatically set the value according to the input type string

## EXAMPLES

```
close all; set(gcf,'unit','pixels');
h = uicontrol('style','popupmenu','pos',[100 100 200
20],'string','filter example');
filterUI(h,'2nd order Butterworth');
filtertype = popupstr(h)
```

## NOTE

To get the filter type from the UI, use *popupstr*

## ROUTINES CALLED

## SEE ALSO

# axis2fig

## SYNOPSIS

hnew = axis2fig(hold)

## INPUTS

hold: original handle of the axis to be copies

## OUTPUT

hnew: the handle of the new figure

## DESCRIPTION

axis2fig copies all visible components on a axis to a new figure, so all components can be re-scaled to normal size to be printed

## EXAMPLES

```
h = axes('unit','pixel','pos',[0 0 100 100]);plot(1:10); legend('plot x');
h = axis2fig(h);
```

## NOTE

The position of legend will be auto put in one of the four corners

## ROUTINES CALLED

## SEE ALSO

# setpopupvalue

## SYNOPSIS

setpopupvalue(h,s);

## INPUTS

h: handle of popup or listbox
s: string to be matched

## OUTPUT

none

## DESCRIPTION

SETPOPUPVALUE sets the value of popup or listbox to match the specified string. Exact match of lower case is required

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

# Animation, Viewers, and Other

## List of Animation, Viewers and Other Routines

| | |
|---|---|
| alias2rgb: | convert an alias of a color to RGB color |
| anim_dyn_1st: | generate the 1st animation frame for an inverse or a forward dynamic model |
| anim_dyn_ith: | generate the ith animation frame for an inverse or a forward dynamic model |
| read_asf: | read an ASCII TekScan data file |
| anim_asf: | animate pressure data measured by TekScan |
| xyviewer: | see Appendix B |
| stickviewer: | see Appendix C |

# alias2rgb

## SYNOPSIS

rgb = char2rgb(c)

## INPUTS

c: character symbol of a color

## OUTPUT

rgb: rgb representation of the color

## DESCRIPTION

ALIAS2RGB converts a color alias to RGB color

## EXAMPLES

## NOTE

Alias of colors supported are listed as follows

| | |
|---|---|
| y | yellow |
| m | magenta |
| c | cyan |
| r | red |
| g | green |
| b | blue |
| w | white |
| k | black |

## ROUTINES CALLED

## SEE ALSO

# anim_dyn_1st

## SYNOPSIS

h = anim_dyn_1st(SYSTEM,BODY);

## INPUTS

| | |
|---|---|
| SYSTEM: | system description structure |
| BODY: | body description structure |

## OUTPUT

| | |
|---|---|
| h: | handles of graphical objects representing the bodies |

## DESCRIPTION

ANIM_DYN_1st draws the first frame of an inverse or a forward dynamical model given the model description and time trace of model response. It also sets up the axis property.

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

# anim_dyn_ith

## SYNOPSIS

h = dyn_anim_ith(iframe,time,SYSTEM,BODY);

## INPUTS

| | |
|---|---|
| iframe: | the number of the frame to be displayed |
| time: | time vector |
| SYSTEM: | system description structure |
| BODY: | body description structure |

## OUTPUT

| | |
|---|---|
| h: | handles of graphical objects representing the bodies |

## DESCRIPTION

ANIM_DYN_ith draws the $i^{th}$ frame of an inverse or a forward dynamic model

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

# read_asf

## SYNOPSIS

[INFO,P] = read_asf(asffile,maxframe);

## INPUTS

asffile: ascii tekscan data file
maxframe: (option) max. number of frames to read from the file
default is to read all the frames

## OUTPUT

INFO: information structure of the tekscan data with the following fields
'sensor_type'
'rows'
'cols'
'units'
'row_spacing'
'row_spacing_units'
'col_spacing'
'col_spacing_units'
'noise_threshold'
'scale_factor'
'exponent'
'seconds_per_frame'
'movie_filename'
'start_frame'
'end_frame'

P: pressure data saved as a cell, each cell element is a matrix of data (rows x cols)

## DESCRIPTION

read_asffile reads an ASCII Tekscan data file

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

anim_asf

# anim_asf

## SYNOPSIS

M = anim_asf(INFO,P);

## INPUTS

INFO: information structure of the tekscan data with the following fields
'sensor_type'
'rows'
'cols'
'units'
'row_spacing'
'row_spacing_units'
'col_spacing'
'col_spacing_units'
'noise_threshold'
'scale_factor'
'exponent'
'seconds_per_frame'
'movie_filename'
'start_frame'
'end_frame'

P: pressure data saved as a cell, each cell element is a matrix of data (rows x cols)

## OUTPUT

M: matlab movie data from the animation

## DESCRIPTION

anim_asf generates the animation of a set of Tekscan test data

## EXAMPLES

## NOTE

## ROUTINES CALLED

## SEE ALSO

read_asf

# 5. Utilities Routines

# Math Routines

## List of Math Routines

| | |
|---|---|
| cross2d: | 2D cross product |
| isint: | check if input numerical variable is integer |
| isrealnum: | check if input numerical variable is real |
| unit: | normalize a matrix |
| dxdt: | calculate time derivatives of a uniformly spaced signal |
| matfiltfilt: | filter uniformly spaced signal with a double Butterworth filter |
| power_spec: | calculate power spectrum of a time-domain signal |
| r_times_v: | rotate 2D or 3D vectors |

# cross2d

## SYNOPSIS

c = cross2d(a,b);

## INPUT:

a: a 2D vector
b: a 2D vector

## OUTPUT:

c: the cross procuct (a number)

## DESCRIPTION

CROSS2D calculates the cross product of two 2D vectors

## EXAMPLES

```
c1 = cross2d([1 2],[1 2]);
c2 = cross2d([10 0],[1 1]);
```

## NOTE

Cross product is not commutative, which means the result depends on the sequence of the two vectors

## ROUTINES CALLED

## SEE ALSO

# isint

## SYNOPSIS

status = isint(a,asize)

## INPUT:

a: number to be checked
asize: (optional) size of a to be expected

## OUTPUT:

status: 1 true; 0 for false

## DESCRIPTION

ININT check if *a* is a numerics integer. The size of *a* can also be checked

## EXAMPLES

isint(a) check if all elements of 'a' is integer
isint(a,[1 1]) check if 'a' is a integer scalar
isint(a,[0 1]) check if 'a' is a integer column vector
isint(a,[0 2]) check if 'a' is a integer max with 2 columns
isint(a,[1 0]) check if 'a' is a integer row vector
isint(a,[2 0]) check if 'a' is a integer max with 2 rows
isint(a,[4 6]) check if 'a' is a integer max of size 4x6

## NOTE

Use zero to indicate the length of a row or a column can be variable

## ROUTINES CALLED

## SEE ALSO

isrealnum

# isrealnum

## SYNOPSIS

status = isrealnum(a,asize)

## INPUT:

a: number to be checked
asize: (optional) size of a to be expected

## OUTPUT:

status: 1 true; 0 for false

## DESCRIPTION

isrealnum checks if *a* is a numerical real value. The size of *a* can also be checked

## EXAMPLES

isrealnum(a) check if all elements of 'a' is real
isrealnum(a,[1 1]) check if 'a' is a real number
isrealnum(a,[0 1]) check if 'a' is a real column vector
isrealnum(a,[0 2]) check if 'a' is a real max with 2 columns
isrealnum(a,[1 0]) check if 'a' is a real row vector
isrealnum(a,[2 0]) check if 'a' is a real max with 2 rows
isrealnum(a,[4 6]) check if 'a' is a real max of size 4x6

## NOTE

use zero to indicate the length of a row or a column can be variable

use the isrealnum to avoid conflict with builtin isreal function

## ROUTINES CALLED

## SEE ALSO

isint

# unit

## SYNOPSIS

U = unit(A,dim)

## INPUT:

A: matrix data
dim: option of perfroming the calculation
dim=0 make the matrix a unit matrix
dim=1 make every column of the matrix a unit vector
dim=2 make every row of the matrix a unit vector

## OUTPUT:

U: output matrix data

## DESCRIPTION

UNIT normalizes the input matrix or its column or row vectors

## EXAMPLES

```
A = rand(10,4)
Umatrix = unit(A,0);
Ucol = unit(A,1)
Urow = unit(A,2)
```

## NOTE

## ROUTINES CALLED

## SEE ALSO

# dxdt

## SYNOPSIS

xn = dxdt(X,dt,order);

## INPUTS

X: sample, X can be a vector, matrix or a 3D matrix
dt: sampling spacing
order: the order of derivative (1 or 2)
xn: deriviate

## OUTPUT

xn: nth order derivative of original data

## DESCRIPTION

DXDT calculates the $n^{th}$ derivatives of X. X should be uniformly sampled with a spacing dt. If X is a 2D or 3D matrix, it is differentiated column-wisely. *order* is one or two with default being one

## EXAMPLES

```
X = rand(100,5);
dx = dxdt(X,0.1,1);
ddx = dxdt(X,0.1,2);
```

## NOTE

1. forward difference is used for the 1st element; backward difference is used for the last element; and central difference is used for all the other
2. 1st and last element of the second order derivatives are the linear exterpolation of the neighboring values

## ROUTINES CALLED

## SEE ALSO

# matfiltfilt

## SYNOPSIS

xf = matfiltfilt(dt, fcut, N, X);

## INPUT:

dt: sampling rate
fcut: cutoff frequency (Hz) fcut must <= nyquist freq
N: order of the filter (usually 2 or 4)
X: sample, X can be a column vector, a matrix or a 3d matrix

## OUTPUT:

xf: filtered data

## DESCRIPTION

MATFILTFILT filters a uniform input signal in time domain by a lower-pass double Butterworth filter of specified order

## EXAMPLES

```
X = rand(100,1);
xf = matfiltfilt(0.01,10,2,X);
plot(1:100,X,'r:',1:100,xf);
legend('original signal','filtered signal');
```

## NOTE

*fcut* must be smaller than nyquist freqency (1/dt/2)

## ROUTINES CALLED

butter: in matlab/signal toolbox

## SEE ALSO

# power_spec

## SYNOPSIS

[fs,Freq,Power] = power_spec(T,X);

## INPUT:

T: uniformly spaced time vector
X: input signal in time domain

## OUTPUT:

fs: samping frequency
Freq: frequence vector
Power: Output power spectrum

## DESCRIPTION

POWER_SPEC calculates power spectrum of input signal in time domain by performing fast Fourier transformation

## EXAMPLES

```
T = 1:100;
X = rand(1,100);
 [fs,Freq,Power] = power_spec(T,X);
plot(Freq,Power);
```

## NOTE

Frequency is shift by half the Nyquist frequency to make it symmetric

## ROUTINES CALLED

## SEE ALSO

# r_times_v

## SYNOPSIS

V = r_times_v(R,v);

## INPUT:

R: 2x2, nx4 (2D time trace), 3x3, nx9 (3D time trace) matrix
v: a length of 2 or 3 vector, or nx2 (2D time trace), nx3 (time trace)

## OUTPUT:

V: rotated vector(s)

## DESCRIPTION

R_TIMES_V rotates a 2D or 3D vector or its time traces by the times the vector with a 2D or 3D rotational matrix or its time traces

## EXAMPLES

Example #1

```
R = [1 1 1; 2 2 2; 3 3 3];
v = [1 2 3]';
V = r_times_v(R,v);
```

Example #2 (for time trace, R is put columnwise)

```
R = [1 1 1 2 2 2 3 3 3
     1 0 3 4 5 0 1 3 2];
v = [1 2 3
     0 0 1];
V = r_times_v(R,v);
```

## NOTE

## ROUTINES CALLED

## SEE ALSO

# String Routines

## List of String Manipulation Routines

| | |
|---|---|
| parchar: | use partial of ASCII table to remove preceding and trailing blanks, tabs, special characters, etc |
| sepchar: | separate a string into a cell array (blank, tab delimited) |
| dirDirs: | get the name of all directories in a designated directory |
| dirFiles: | get the name of all files in a designated directory |
| isdir: | determine if the specified directory exists |
| isfile: | determine if the specified file exists |
| addFileExt: | check and add a designated extension to a file |
| isvar_wdof: | determines if a string is a valid variable name. Array DOF may be included |
| str2realmat: | convert a string matrix to a numeric real matrix |
| fieldparts: | separate full field name (from top structure to field) into structure path and field name |
| fullfield: | construct the full field name (from top structure to field) from the structure path and fieldname |

# parchar

## SYNOPSIS

s = parchar(s)

## INPUT:

s: input string

## OUTPUT:

s: output string with only characters with ascii table 33-125

## DESCRIPTION

PARCHAR uses only the partial ASCII character (32-125) table of matlab, s can be a string or a string cell. Preceding and trailing spaces and tabs are also eliminated; tabs inside the text is converted into spaces

## EXAMPLES

```
parchar('  a b');
parchar({'cha 1',' cc 2'});
```

## NOTE

## ROUTINES CALLED

## SEE ALSO

sepchar

# sepchar

## SYNOPSIS

c = sepchar(s)

## INPUT:

s: input string

## OUTPUT:

c: output cell of strings

## DESCRIPTION

SEPCHAR separates a character *'s'* into a cell, with each element corresponds to the part of character separated by space, tab, etc

## EXAMPLES

sepchar(' 1 3 4');

## NOTE

## ROUTINES CALLED

## SEE ALSO

parchar

# dirDirs

## SYNOPSIS

d = dirDirs(p,option);

## INPUT:

p: directory (default is the current directory)
option: option = 1: ignore '.' and '..'
option = 0, '.' and '..' will be included

## OUTPUT:

d: directory names saved in a cell

## DESCRIPTION

dirDirs get the subdirectories in a directory

## EXAMPLES

dirDirs
dirDirs('c:\')

## NOTE

## ROUTINES CALLED

## SEE ALSO

dirFiles

# dirFiles

## SYNOPSIS

f = dirFiles(p);

## INPUT:

p: directory (default is the current directory)

## OUTPUT:

f: all filenames in the directory saved in a cell

## DESCRIPTION

dirFiles gets the files in a directory

## EXAMPLES

```
dirFiles
dirFiles('c:\')
```

## NOTE

## ROUTINES CALLED

## SEE ALSO

dirDirs

# isdir

## SYNOPSIS

result = isfile(dirname)

## INPUT:

| | |
|---|---|
| dirname: | the name of a directory |

## OUTPUT

| | |
|---|---|
| result: | =1 directory exists;<br>=0 directory does not exist |

## DESCRIPTION

ISDIR checks if *dirname* is a directory

## EXAMPLES

## ROUTINES CALLED

## SEE ALSO

isfile

# isfile

## SYNOPSIS

result = isfile(filename)

## INPUT:

filename: the name of a file

## OUTPUT

result: =1 file exists;
=0 file does not exist

## DESCRIPTION

ISFILE checks if *filename* is a file

## EXAMPLES

## ROUTINES CALLED

## SEE ALSO

isdir

# addFileExt

## SYNOPSIS

fname = addFileExt(filename,ext);

## INPUT:

| | |
|---|---|
| filename: | input filename |
| ext: | file extension to be added(not dot) |

## OUTPUT:

| | |
|---|---|
| fname: | filename with extension added |

## DESCRIPTION

ADDFILEEXT checks if the designated extension is in the *filename* and, if not, adds the designated extension to the file name

## EXAMPLES

fname = addFileExt('fname.','.txt')

## NOTE

1. the dot in extension does not matter
2. lower or upper case is neglected

## ROUTINES CALLED

fileparts

## SEE ALSO

# isvar_wdof

## SYNOPSIS

[status,var,dof] = isvar_wdof(c)

## INPUT:

c: variable name to be checked

## OUTPUT:

status: 1 if is a valid name, 0 not
var: the variable name
dof: dof of the variable

## DESCRIPTION

ISVAR_WDOF determines if c is a valid variable name. A valid variable name must start with a letter or _ and contains no special or blank characters. DOF of the variable can be included with (idof) after the variable name.

## EXAMPLES

## NOTE

## ROUTINES CALLED

isvarname

## SEE ALSO

# str2realmat

## SYNOPSIS

[mat,status] = str2realmat(s)

## INPUT:

s: input string matrix or a cell with each element a string row

## OUTPUT:

mat: output numerical array

status: 1: successful;

0: error in string matrix; (size doesn't match, NaN present)

## DESCRIPTION

STR2REALMAT converts a string matrix to a numeric array, which is the extension of str2double and str2num

## EXAMPLES

## NOTE

## ROUTINES CALLED

sepchar;

## SEE ALSO

# fieldparts

## SYNOPSIS

[fpath,f] = fieldparts(ff)

## INPUT:

ff: full structure field name

## OUTPUT:

fpath: structure field path
f: field name

## DESCRIPTION

FIELDPARTS separates full field name (from top structure to field) into the structure path and field name

## EXAMPLES

[sp,f] = fullfield('S.S1.S(2).field1')

## NOTE

## ROUTINES CALLED

## SEE ALSO

fullfield

# fullfield

## SYNOPSIS

ff = fullfield(fpath,f)

## INPUT:

fpath: structure field path
f: field name

## OUTPUT:

ff: full structure field name

## DESCRIPTION

FULLFIELD constructs the full field name (from top structure to field) from the structure path and fieldname

## EXAMPLES

ff = fullfield('S.S1.S(2)','field1')

## NOTE

## ROUTINES CALLED

## SEE ALSO

fieldparts

# A. TmtEditor

# Introduction

## What is TmtEditor

**TmtEditor** is a GUI based tool to browser and edit TMT files. Refer to Data I/O section for details on TMT files.

## Features

- Easy browsing of complicated structured data
- Support generating new TMT files using existing template files
- Various ways of inputting data
- Flexible control over user's accessibility to data editing

## Start TmtEditor

**TmtEditor** is delivered in one of the following three versions

- **MEX version:** MEX version of **TmtEditor** is to be used in Matlab environment. To start it in Matlab, type *'tmteditor'* in Matlab command window.

---

**Note:** To use TmtEditor in Matlab, the right path and default setting has to be setup for the directory where TmtEditor MEX routines are installed. To setup the default setting (for first time use or when the default setting is corrupt, type *'tmtsetup'* in Matlab command window

---

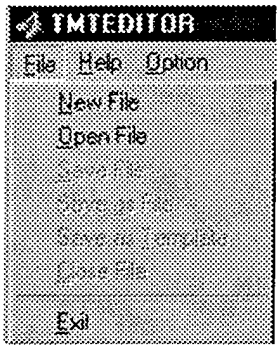
- **Standalone version:** Standalone version of **TmtEditor** is delivered in a single installation file **"install_TmtEditor.exe"**, which can be installed and run as a standard DOS/Window executable program.
- **Application version: TmtEditor** can also be integrated as part of application software as a data viewer. In this case, it can only be used with the software.

# GUI Components

This section describes several GUI components of **TmtEditor** and their common use.

## File Menu

**File menu** performs file operations




## Help Menu

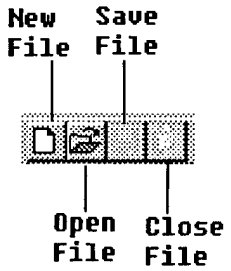
**Help menu** provides access to help information


## Option Menu

**Option menu** allows the user to select different accessibility to data editing

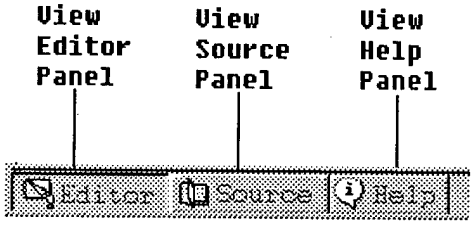

## TmtEditor Toolbar

**TmtEditor Toolbar** provides easy access to common file operations:

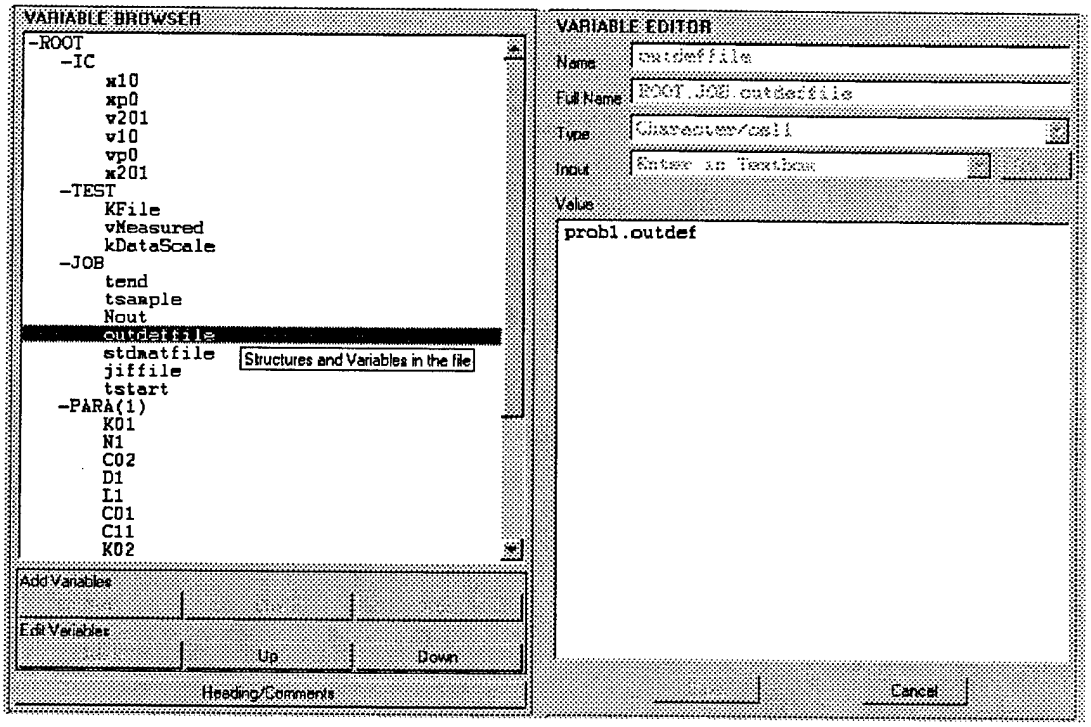


## TmtEditor Viewbar

**TmtEditor Viewbar** allows the change of different view panels



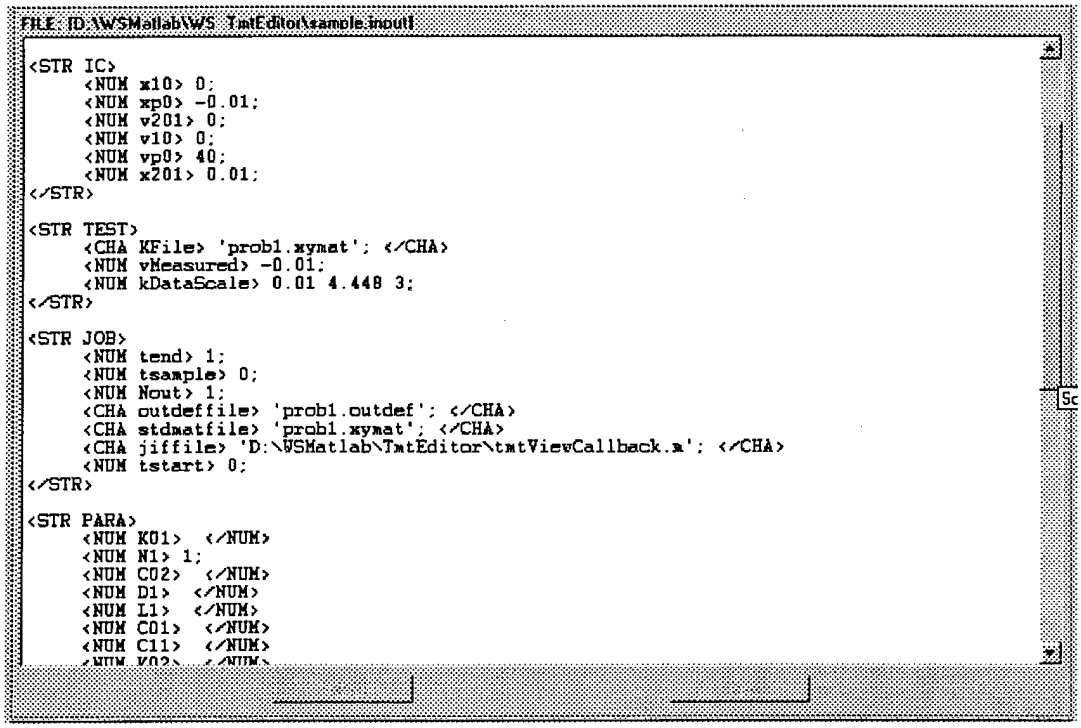

## Editor Panel




**Editor Panel** includes a **Data Browser**, a **Variable Editor**, and other UI components and allows the browsing and editing of TMT files

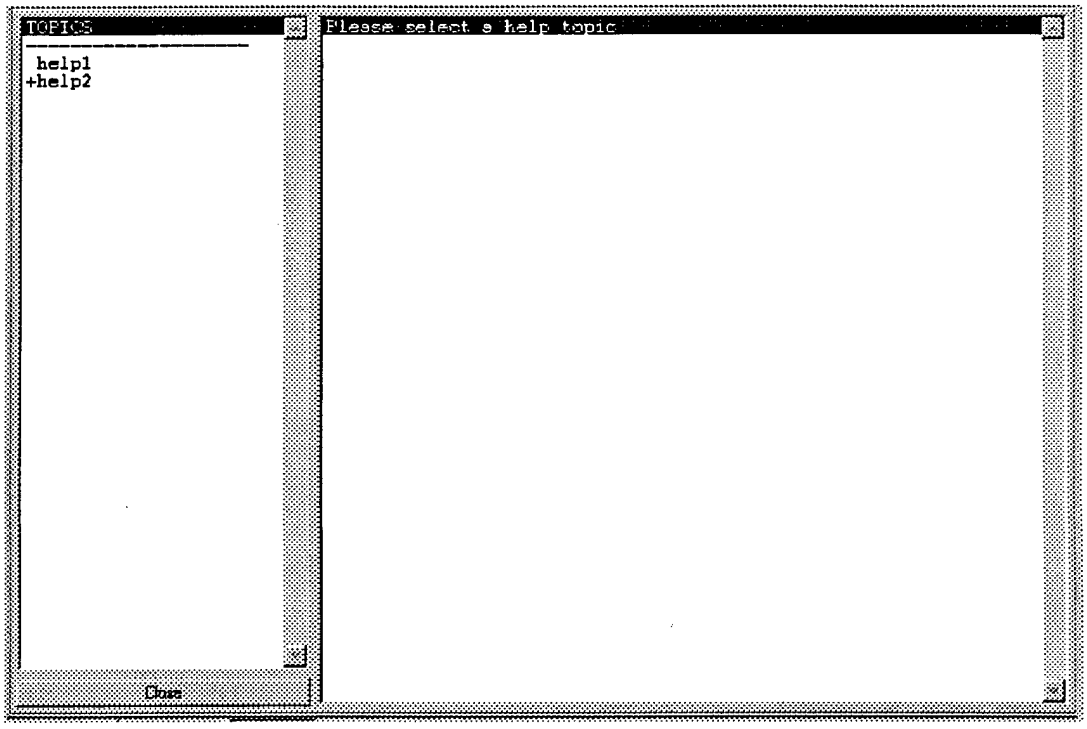
## Source Panel

**Source panel** lists the source code of the file being edited.




## Help Panel

**Help Panel** provides the browsing of help information on **TmtEditor**



# Use TmtEditor

## Change View Panel

To change the view panel, click on the buttons on the **TmtEditor Viewbar.**

## File Operation

To open a TMT file, follow the following steps

- Select **Open File** from **File Menu;**

  or push the **Open File** button on **TmtEditor Toolbar;**

- Browse for the file to open in the popup **File Browse Window**

To close a data file, follow the following steps

- Select **Close File** from **File Menu;**

  or push the **Close File** button on **TmtEditor Toolbar;**

- If the file has be modified, a popup window will show up asking for saving or discarding the changes.

To save modifications to a TMT file,

- Select **Save File** from **File Menu;**

  or push the **Save File** button on **TmtEditor Toolbar;**

To save the file as another TMT file,

- Select **Save as File** from **File Menu;**
- Browse or enter the name for the new file in the popup **File Browse Window**

To save the file as an TMT template file,

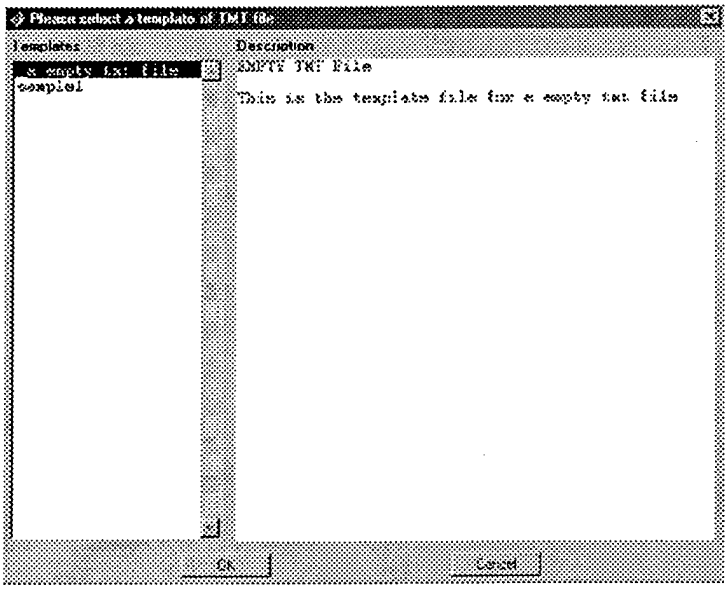
- Select **Save as Template** from **File Menu;**
- Enter the name for the template file in the popup **File Browse Window**

To create a new TMT file

- Select **New File** from **File Menu;**

  or push the **New File** button on **TmtEditor Toolbar;**

- Enter the name for the new file in the popup **File Browse Window**
- Select the template file to use for the new file in the popup **Template Selection Window** as shown bellow, and click on the **OK button.**




## Browse in a TMT file

The data in a TMT file can be browsed in the **Variable Browser.**

- The first item in the browser is ROOT item, which is always there and cannot be edited
- A '+' or a '-' sign ahead of a variable indicates that it is a structure. Double click on a structure will expand or shrink it in the browser
- When a variable is selected, details on the variable will be listed in the **Variable Editor** to the right of the browser

## Enable/disable template editing

By enabling template editing, all properties of all variables in the TMT file can be edited. If template editing is disabled, only the values of the variables given in the file can be changed. This allows data to follow exactly the format in the original TMT file (or a template file).

To enable or disable template editing, select **Enable/Disable template editing** from **Option Menu;**

## Edit Variables

### Add a numeric variable

- Select a structure variable in the **Variable Browser** and click on the **NUM** button to add a numeric variable under the structure selected.
- The new variable will be named 'new_num' and has a default value of being an empty matrix. The name and value for the new variable can be modified in the **Variable Editor.**

### Add a character variable

- Select a structure variable in the **Variable Browser** and click on the **CHA** button to add a character variable under the structure selected.
- The new variable will be named 'new_char' and has a default value of being an empty string. The name and value for the new variable can be modified in the **Variable Editor.**

### Add a structure variable

- Select a structure variable in the **Variable Browser** and click on the **Struct** button to add a structure variable under the structure selected.
- The new variable will be named 'new_stru', which contains an empty numeric variable 'new_num' and an empty string 'new_char', The new structure and the variables under the structure can be modified in the **Variable Editor.**

### Move up/down a variable

- Select a variable in the **Variable Browser** and click on the **Up** or **Down** button to move a variable up or down in the TMT file

### Delete a variable

- Select a variable in the **Variable Browser** and click on **Delete** button to remove the variable

---

**Note:** If a structure is to be deleted, all "children" items under the structure will also be deleted; if the numeric variable or the string variable to be deleted is the last child of a structure, the structure will be deleted along with the variable. The only exception is for the ROOT item, which can never be deleted.

---

### Change the name of a variable

- Change the name in the **Name input box** on the **Variable Editor**
- Click on the **Save** button on the **Variable Editor**

---

**Note:** Array of structure is supported. The index of a structure is indicated by following the name of the structure by the index in the brackets

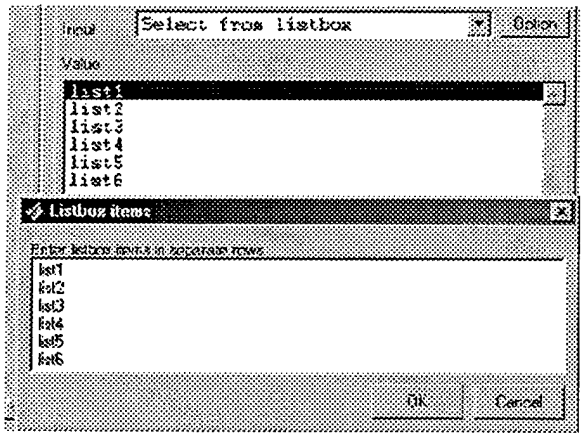
---

### Change the input method of a string variable

- Select the input method in the **Input Method Selection Box** on the **Variable Editor**
- If the input method is **"browse for a file"**, a **Browse** button will appear. Click on the button to select or enter the name of the file. The file name will be used as the value of the string variable.

Click on the **Option** button to change the file extension to be used for browsing files. The following is an example of how file extension is specified


- If the input method is **"Select from listbox",** the value of the string should be selected from the list box underneath the **Input Method Selection Box.** Click on the **Option** button the items to be listed in the listbox.




## Add heading to a TMT file

To add or modify the heading a TMT file, click on the **Heading/Comments** button on the **Editor View Panel.** And enter the new heading in the popup window.

## Get Quick Help

To get quick help and information about **TmtEditor,**

- Push **Show Help** button on **TmtEditor Viewbar;**

  Or slect **Help TmtEditor** from **Help Menu**

- Select a topic to display the help message about the topic

# B. XY Plot Viewer

# Introduction

## What is XY plot viewer

**XYViewer** is graphical viewer to visualize the vectors or matrices stored in JIF ASCII files or STDMAT binary files.

## Features

- Support STDMAT and JIF ASCII file formats, where the value of each "channel" of data is stored in a column vector and associated with a *name, label, units*. In STDMAT files, the data channels can also be grouped under different *group names*;
- Multiple data files can be opened in the same viewer. This allows the comparison of data from different files;
- Support print the plot as PS, EPS, EMF, and BITMAP files;
- Support output plot data as space, tab or comma delimited ASCII files;
- A simple GUI layout allows the easy access and plotting of data;
- Support overlay of curves on a single plot;
- Easy access to data definition and peak values;
- Many axis properties, such as color, grid, box, legend, axis label, title, can be edited;
- Many line properties ,such as style, width, color, marker and marker size, can be edited;
- Automatically synchronized with additional data viewer, such as **stickViewer**, to visualize data on fly.

## Start XY Plot Viewer

**XYViewer** is delivered in one of the following three versions

- **MEX version**: MEX version of **XYViewer** is to be used in Matlab environment. To start it in Matlab, type *'xyviewer'* in Matlab command window.

---

**Note:** To use XYViewer in Matlab, the right path has to be setup for the directory where XYViewer MEX routines are installed

---

- **Standalone version:** Standalone version of **XYViewer** is delivered in a single installation file **"install_xyviewer.exe"**, which can be installed and run as a standard DOS/Window executable program.

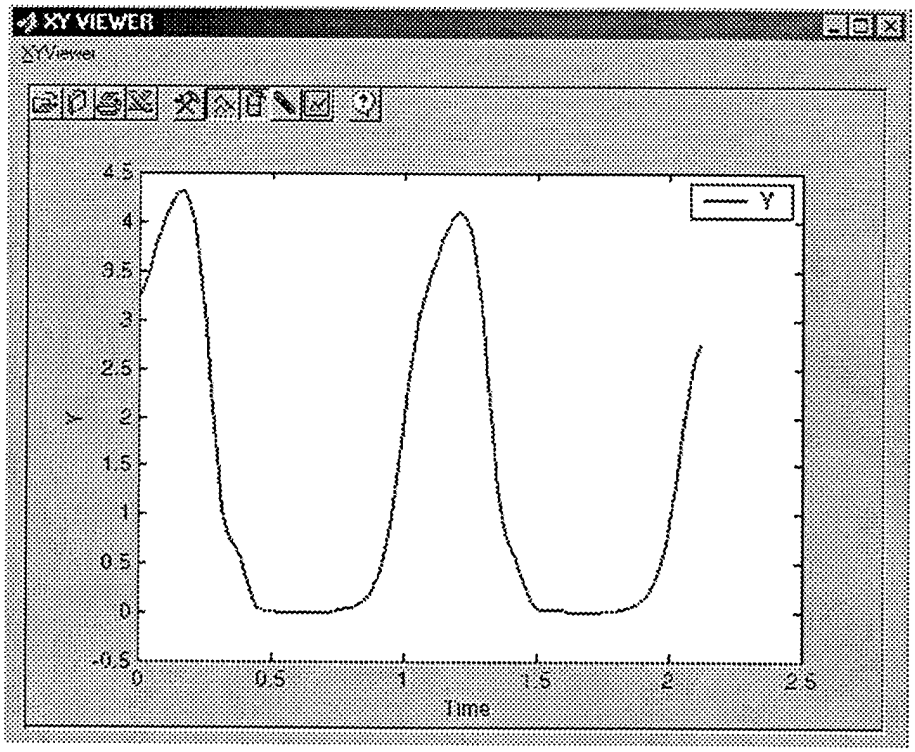
- **Application version: XYViewer** can also be integrated as part of application software as a data viewer. In this case, it can only be used with the software.

# GUI Components

This section describes several GUI components of **XYViewer** and their common use.

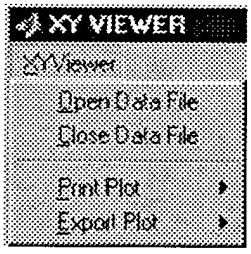
## XY Plot Axis

**XY Plot Axis** is where the data is plotted.



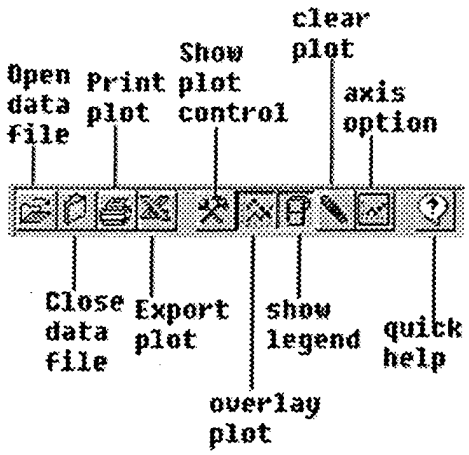

## XYViewer Menu

The **XYViewer Menu** performs file operations, such as opening and closing of data files, as well as printing and exporting of a plot.



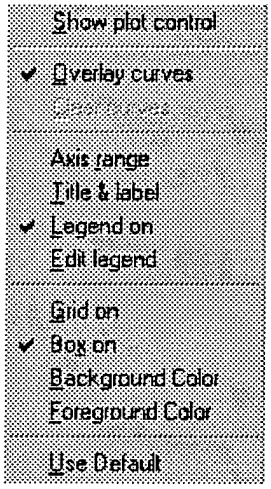

## XYViewer Toolbar

**XYViewer Toolbar** provides easy access to common operations:



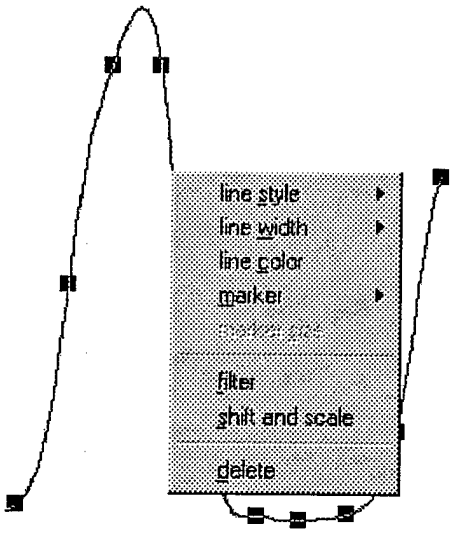

## Axis Property Context Menu

**Axis Property Context Menu** is launched by right clicking mouse inside the **XY Plot Axis** but not over any curve plotted inside. It provides options to edit the properties of the axis.



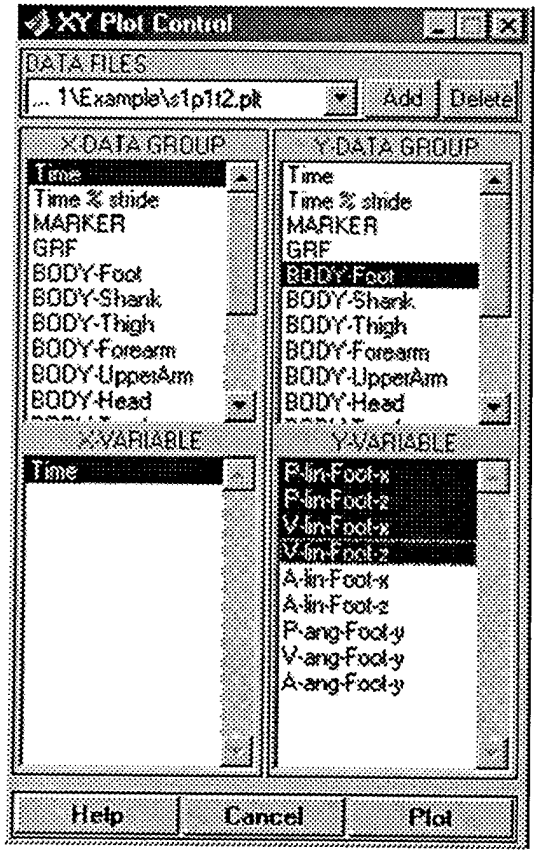

## Line Property Context Menu

**Line Property Context Menu** is activated by right clicking mouse over a curve inside the **XY Plot Axis**. It provides options to edit line properties of the curve selected.




## XY Plot Control

**XY Plot Control** is a popup window that displays the file(s) being opened and data inside a selected file. It can be used to open or close data file(s) and to plot data.



# Use XY Plot Viewer

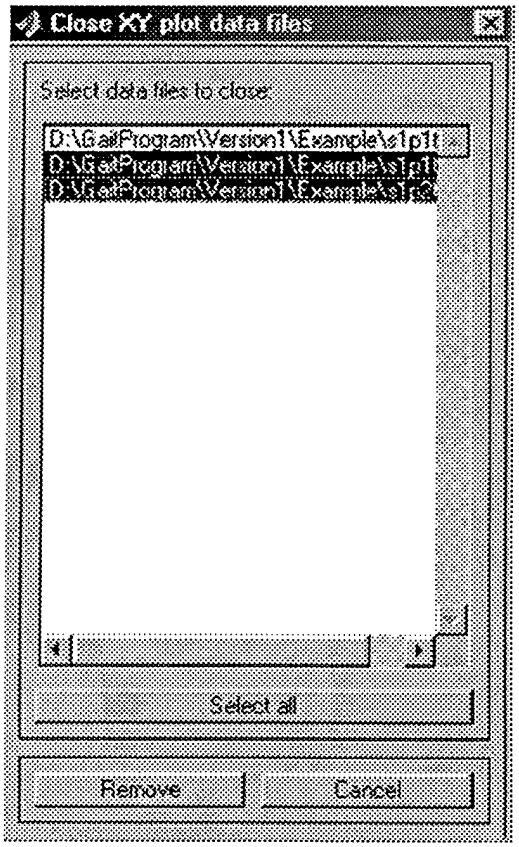
## Open/Close XY Data File

To open a data file, follow the following steps

- Select **Open Data File** from **XYViewer Menu;**
  or push the **Open Data File** button on **XYViewer Toolbar;**
  or push the **Add** button inside **XY Plot Control**
- Browse for the file to open in the popup **File Browse Window**

To close a data file, follow the following steps

- Select **Close Data File** from **XYViewer Menu;**
  or push the **Close Data File** button on **XYViewer Toolbar;**
  or push the **Delete** button inside **XY Plot Control**
- Select the file(s) to close in the popup **Close XY plot data files** window and click **Remove** button to close the data file(s).




## Print/Export a Plot

To print a plot on the **XY Plot Axis,** follow the following steps

- Select **Print Plot** from **XYViewer Menu;**

  or push the **Print** button on **XYViewer Toolbar;**

- Select **Default Printer** to print to the default printer
- Select the **type of file** and enter the file name in the popup **file browser window** to print the plot as a file. Current the following types of files are supported
  - Postscript files(*.ps)
  - Encapsulated postscript files (*.eps)
  - Window meta files (*.emf)
  - Bitmap files (*.bitmap)

To export the curves plotted in the **XY Plot Axis** to an ASCII file, follow the following steps

- Select **Export Plot** from **XYViewer Menu;**

  or push the **Export** button on **XYViewer Toolbar;**

- Select the **type of file** and enter the file name in the popup **file browser window** to export the data. Current the following types of files are supported
  - Space/tab delimited ASCII (*.dat)
  - Comma delimited ASCII files (*.csv)
  - JIF ASCII files (*.jif)

## Plot Data

Following the following steps to plot data

- Activate the **XY Plot Control**. This can be done by doing one of the following:
  - Push **Show XY** button on **XYViewer Toolbar;**
  - In **Axis Property Context Menu** (by right click mouse in the **XY Plot Axis**), select **Show Plot Control;**
  - Push **Axis Properties** button on **XYViewer Toolbar** and select **Show Plot Control;**
- Select the right data file in the **Data File** popup window
- In **X Data Group** listbox, select the group name of X-axis variable
- In **X Variable** listbox, select the X-axis variable
- In **Y Data Group** listbox, select the group name of Y-axis variable(s)
- In **Y Variable** listbox, select the Y-axis variable(s)

- Click the **Plot** button to plot the selected Y-variable(s) vs. X-variable.

## Edit Axis Properties

- Activate the **Axis Property Context Menu** by doing one of the following:
  - Push **Axis Properties** button on **XYViewer Toolbar;**
  - Right click mouse in the **XY Plot Axis.**
- Select one of the following properties to edit
  - **Axis range**
  - **Title & Label**
  - **Legend on**
  - **Edit legend**
  - **Grid on**
  - **Box on**
  - **Background color**
  - **Foreground color**

## Edit Line Properties

- Activate the **Line Property Context Menu** by right clicking mouse over the curve whose properties is to be edited
- Select one of the following properties to edit
  - **Line style**
  - **Line width**
  - **Line color**
  - **Marker**
  - **Marker size**

## Show/Hide Legend

The legend for the curves plotted can be displayed or removed from **XY Plot axis** by one of the following

- Push **Legend on/off** button on **XYViewer Toolbar;**
- Or select **Legend on/off** in **Axis Property Context Menu** (by right click mouse in the **XY Plot Axis**)

## Enable/Disable Overlaying Plots

Overlaying plot can be enabled or disabled by one of the following

- Push **Overlay curve** button on **XYViewer Toolbar;**
- Or select **Overlay curves** in **Axis Property Context Menu** (by right click mouse in the **XY Plot Axis**)

### Clear a Plot or Delete a Curve

One of the following will clear the plot

- Push **Clear** button on **XYViewer Toolbar;**
- Or select **Clear curves** in **Axis Property Context Menu** (by right click mouse in the **XY Plot Axis**)

To delete only one curve from the plot, follow the following steps

- Activate the **Line Property Context Menu** by right clicking mouse over the curve whose properties is to be deleted
- Select **Delete**

### Get Quick Help

To get quick help and information about **XYViewer,**

- Push **Help** button on **XYViewer Toolbar;**
- Select a topic to display the help message about the topic

# C. Stick Plot Viewer

# Introduction

## What is Stick plot viewer

StickViewer is a three-dimensional viewer to visualize stick plots.

## Features

- Simple GUI provides easy access to visualization and animation
- Support print the plot as PS, EPS, EMF, and BITMAP files;
- Support output stick animations as Matlab movies;
- Many axis properties, such as color, grid, box, legend, axis label, title, can be edited;
- Many stick properties ,such as style, width, color, marker and marker size, can be edited;
- Automatically synchronized with **XYViewer** to visualize data on fly.

## Start STICK Plot Viewer

**StickViewer** is delivered in one of the following three versions

- **MEX version**: MEX version of **StickViewer** is to be used in Matlab environment. To start it in Matlab, type *'stickviewer'* in Matlab command window.

---

**Note:** To use **StickViewer** in Matlab, the right path has to be setup for the directory where **StickViewer** MEX routines are installed

---

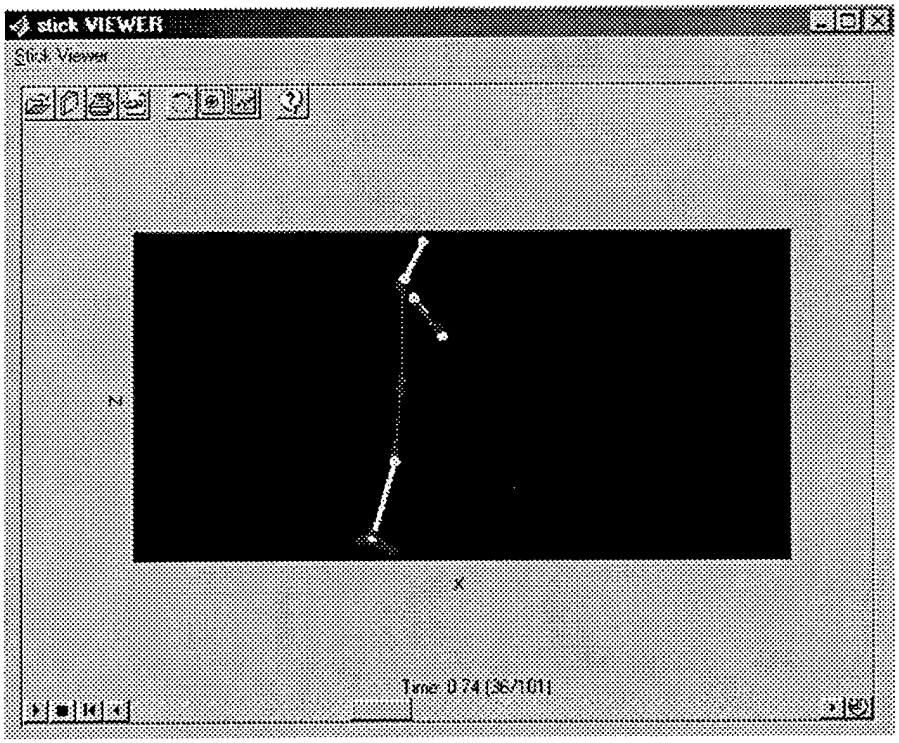
- **Standalone version:** Standalone version of **StickViewer** is delivered in a single installation file **"install_stickviewer.exe"**, which can be installed and run as a standard DOS/Window executable program.
- **Application version: StickViewer** can also be integrated as part of application software as a data viewer. In this case, it can only be used with the software.

# GUI Components

This section describes several GUI components of **StickViewer** and their common use.

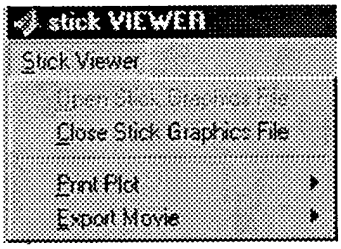
## Stick Plot Axis

**Stick Plot Axis** is where the data is plotted.



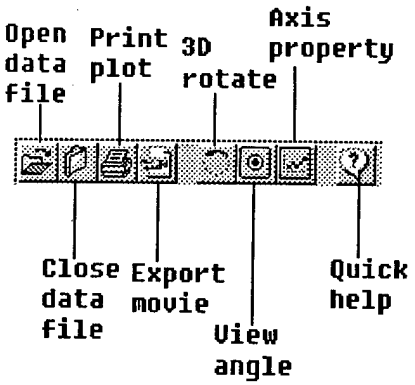

## StickViewer Menu

The **StickViewer Menu** performs file operations, such as opening and closing of data files, as well as printing plot and exporting animation.



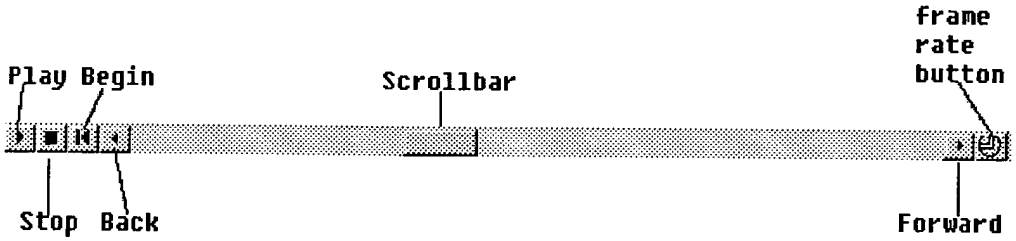

## StickViewer Toolbar

**StickViewer Toolbar** provides easy access to common operations:



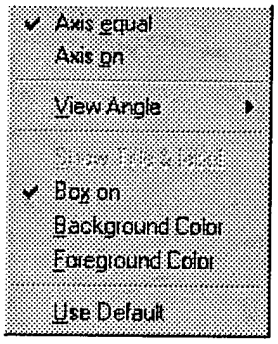

## Stick Animation Toolbar

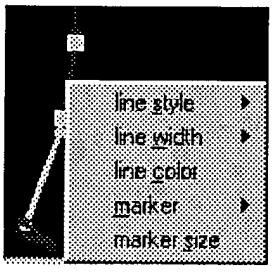
**Stick Animation Toolbar** provides options to control the animation of stick plots.




## Axis Property Context Menu

**Axis Property Context Menu** is launched by right clicking mouse inside the **Stick Plot Axis** but not over any stick. It provides options to edit the properties of the axis.




## Stick Property Context Menu

**Stick Property Context Menu** is activated by right clicking mouse over a stick inside the **Stick Plot Axis**. It provides options to edit line properties of the stick selected.

# Use STICK Plot Viewer

## Open/Close Stick Graphics File

To open a data file, follow the following steps

- Select **Open Stick Graphics File** from **StickViewer Menu;**

  or push the **Open** button on **StickViewer Toolbar;**
- Browse for the file to open in the popup **File Browse Window**
- The first frame of the stick plots will be displayed

To close a stick graphics file, follow the following steps

- Select **Close Stick Graphics File** from **StickViewer Menu;**

  or push the Close button on StickViewer Toolbar;

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**Note:** Stick graphic file is a Matlab binary data file containing the time history of positions and orientations of each stick, as well as the definition of each stick

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## Print a Frame

To print a snapshot of a stick plot frame the following steps

- Select **Print Plot** from **StickViewer Menu;**

  or push the **Print** button on **StickViewer Toolbar;**
- Select **Default Printer** to print the snapshot to the default printer
- Select the **type of file** and enter the file name in the popup **file browser window** to print the snapshot as a file. Currently the following types of files are supported
  - Postscript files(*.ps)
  - Encapsulated postscript files (*.eps)
  - Window meta files (*.emf)
  - Bitmap files (*.bitmap)

## Export an Animation

To export a stick animation, following the following steps

- Select **Export Movie** from **StickViewer Menu;**

  or push the **Export** button on **StickViewer Toolbar;**

- Select the **type of file** and enter the file name in the popup **file browser window** to export the data. Currently only Matlab movie (*.mat) is supported

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**Note:** To convert a Matlab movie file into an AVI file, use *"movie2avi"* command in Matlab

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## Edit Axis Properties

- Activate the **Axis Property Context Menu** by doing one of the following:
  - Push **Axis Properties** button on **StickViewer Toolbar;**
  - Right click mouse in the **Stick Plot Axis.**
- Select one of the following properties to edit
  - **Axis equal:** force all axes to use the same data aspect ratio for
  - **Axis on:** turn on or turn off axis
  - **View angle:** change the view angle of the 3D stick plots
  - **Show Title & lable:** show label for the axes
  - **Box on:** add or remove box from the axis
  - **Background color:** change background of the axis
  - **Foreground color:** change foreground of the axis

## Edit Stick Properties

- Activate the **Stick Property Context Menu** by right clicking mouse over the stick whose properties is to be edited
- Select one of the following properties to edit
  - **Line style**
  - **Line width**
  - **Line color**
  - **Marker**
  - **Marker size**

## Free rotation of Axis

The free rotation of the axis (to change view angle) can be performed by pushing down the **3D rotate** button on **StickViewer Toolbar** and use mouse to rotate the **Stick Plot Axis.**

## Get Quick Help

To get quick help and information about **STICKViewer,**

- Push **Help** button on **STICKViewer Toolbar;**
- Select a topic to display the help message about the topic